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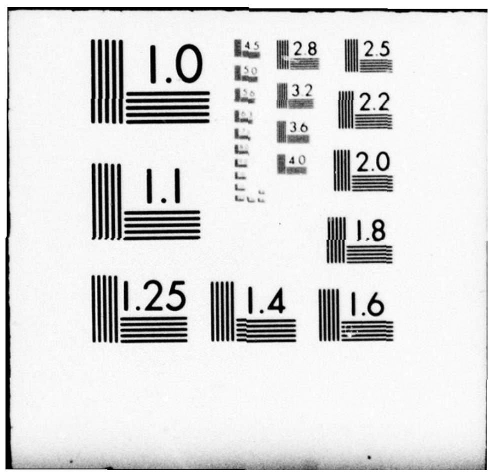
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DREDGED MATERIAL RESEARCH PROGRAM

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TECHNICAL REPORT D-77-23-App-F-Vol-2

HABITAT DEVELOPMENT FIELD INVESTIGATIONS WINDMILL POINT MARSH DEVELOPMENT SITE, JAMES RIVER, VIRGINIA.

APPENDIX F: ENVIRONMENTAL IMPACTS OF MARSH DEVELOPMENT WITH DREDGED MATERIAL: SEDIMENT AND WATER QUALITY.

Volume II: Substrate And Chemical Flux Characteristics Of A Dredged Material Marsh.

by

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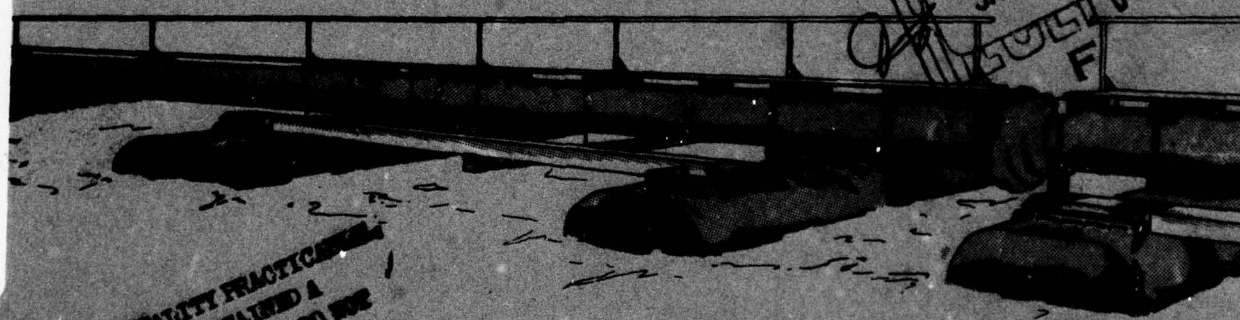

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HABITAT DEVELOPMENT FIELD INVESTIGATIONS, WINDMILL POINT MARSH DEVELOPMENT SITE, JAMES RIVER, VIRGINIA

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IN REPLY REFER TO: WESEV

13 October 1978

SUBJECT: Transmittal of Technical Report D-77-23, Appendix F (Volume II)

TO: All Report Recipients

1. The technical report transmitted herewith represents the results of one of a series of research efforts (work units) undertaken as part of Task 4A (Marsh Development) of the Corps of Engineers' Dredged Material Research Program. Task 4A was part of the Habitat Development Project (HDP) and had as its objective the development and testing of the environmental, economic, and engineering feasibility of using dredged material as a substrate for marsh development.

2. Marsh development using dredged material was investigated by the HDP under both laboratory and field conditions. The study reported herein (comprising Work Units 4A11D, G, and H) was an integral part of a series of research contracts jointly developed to achieve Task 4A objectives at the Windmill Point Marsh Development Site, James River, Virginia, one of six marsh establishment sites located in different geographic regions of the United States. Interpretation of this report's findings and recommendations is best made in context with the other reports in the Windmill Point site series (4A11A-M).

3. This report, "Appendix F: Environmental Impacts of Marsh Development with Dredged Material: Sediment and Water Quality" appears in two volumes and is one of six contractor-prepared appendices published relative to the Waterways Experiment Station's Technical Report D-77-23, entitled "Habitat Development Field Investigations, Windmill Point Marsh Development Site, James River, Virginia; Summary Report" (4A11M). The appendices to the Summary Report are studies that provide technical background and supporting data and may or may not represent discrete research products. Appendices that are largely data tabulations or that clearly have only site-specific relevance were published as microfiche; those with more general application were published as printed reports.

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4. Volume I was entitled "Characteristics of Channel Sediments Before Dredging and Effluent Quality During and Shortly After Marsh Habitat Development." Research described in that document included a chemical and physical evaluation of channel sediment characteristics before dredging and a chemical and physical evaluation of effluent at the habitat development site during active disposal, dewatering, and 3.5 months after disposal was complete. Volume II, entitled "Substrate and Chemical Flux Characteristics of a Dredged Material Marsh," is forwarded herewith. Research described in Volume II included documentation of changes in the physical and chemical properties of the developed marsh substrate and the longer term tidal flux characteristics of nutrient and metallic substances. The relationship between substrate conditions and chemical flux is discussed and all observations are compared with parallel studies conducted in a nearby natural marsh.

5. Data from this report will be included in the Windmill Point Summary Report (4A11M) and synthesized in Technical Reports DS-78-15 and DS-78-16, entitled "Upland and Wetland Habitat Development with Dredged Material: Ecological Considerations" and "Wetland Habitat Development with Dredged Material: Engineering and Plant Propagation," respectively.

John L. Cannon
JOHN L. CANNON
Colonel, Corps of Engineers
Commander and Director

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This volume is the second of a two-volume appendix presenting the results of chemical and sedimentological studies conducted at a dredged material marsh development site located near Windmill Point, on the tidal freshwater James River, 16 km below Hopewell, Virginia.

Sediment and water quality studies conducted before, during, and shortly following dredged material disposal for marsh site construction are presented in Volume I. This volume presents results of substrate sediment studies conducted at the marsh development site and a natural reference marsh 6, 18, and 24 months after site construction. It also compares the physical and chemical transport characteristics of the two marshes based upon monitoring tidal water quality conditions 18 and 24 months following habitat development.

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20. ABSTRACT (Continued).

Sediment cores were collected and processed using techniques designed to document horizontal and vertical physical and chemical gradients and allow comparisons between sampling periods. Temperature, pH, redox potential, water and volatile solids content, particle size composition, mineralogy, cation exchange capacity, and interstitial and total concentrations of nutrients, carbon, and metals were studied. Metal associations with organic, easily and moderately reduceable and residual sediment phases were also examined.

Comparisons between the marsh development site and the natural reference marsh substrate indicated that the reference marsh was more acidic (pH = 6.2 versus 6.7), slightly more oxidized (Eh = +150 versus +115 mV), and contained finer mean size (2 versus 6 μm) and more organic (percent volatile solids - 16 versus 7.5) sediments with higher cation exchange capacity (60 versus 32 meq/100 g). Interstitial and total nutrient and carbon levels in both marshes were similar with a few exceptions. Total Kjeldahl nitrogen in the experimental marsh sediments was lower than levels in the natural marsh. Changes in total Kjeldahl nitrogen concentration appeared to be related to losses during dredging, oxidation losses, and plant uptake of demineralized nitrogen forms. Seasonal changes in sediment pore water levels of dissolved total nitrogen, organic carbon, calcium, iron, and mercury were indicated. Pore water values of dissolved iron and manganese increased during the 18-month period following marsh construction.

Water quality studies were conducted during 48-52 hour tidal sampling programs in August 1976 and January 1977. Temperature, dissolved oxygen, turbidity, pH, alkalinity, and dissolved nutrients, carbon, metals, and other variables were studied. Seasonal mass chemical transport was calculated using topographic and tidal volume data for both marshes.

Analysis of variance identified thirteen variables that were different between both marshes in August and January. Eight were higher at the experimental site: conductivity, total phosphorus, turbidity, orthophosphate, nitrate plus nitrite, calcium, manganese, and volatile organic carbon. Two were higher at the reference marsh: pH and dissolved oxygen.

Mass transport calculations (in units of kg/tidal cycle) for the experimental marsh in August 1976 identified the export of dissolved volatile organic carbon (15), dissolved organic carbon (14), dissolved total nitrogen (8.7), particulate iron (3.4), and dissolved calcium (3.3). Suspended solids (18), dissolved oxygen (14), and total Kjeldahl nitrogen (4) were imported during this period. In January 1977, dissolved organic carbon (15) and dissolved volatile organic carbon (6) were exported while suspended solids (44), total Kjeldahl nitrogen (3.9), particulate iron (3.7), and dissolved total nitrogen (2.4) and dissolved calcium (2.3) were imported.

Similar calculations for reference marsh transport identified the August 1976 export of total Kjeldahl nitrogen (73), dissolved organic carbon (69), suspended solids (36), dissolved volatile organic carbon(36), dissolved calcium (26), dissolved oxygen (18), particulate iron (6.1), dissolved nitrate plus nitrite (4.3), dissolved iron (2.0), dissolved zinc (1.0), and dissolved manganese (0.9). Dissolved total nitrogen (18) and ammonium (3.3) were imported. In January 1977, the largest measurable exports included dissolved organic carbon (40), dissolved total nitrogen (29), dissolved total Kjeldahl nitrogen (7.3), and ammonium (4.8). Numerous variables, including suspended solids (40), dissolved calcium (37), dissolved volatile organic carbon (22), particulate iron (21), dissolved oxygen (19), particulate calcium (2.3), and particulate manganese (0.8), were imported to the reference marsh in January 1977. The continuous export of dissolved manganese from both marshes in August and January was offered as an explanation for the lower sediment manganese levels of the older natural marsh at 330 μg/g versus experimental marsh values of 900 μg/g.

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PREFACE

This report contains the results of investigations of the chemical and sedimentological characteristics of the James River Artificial Habitat Development Site and a reference marsh near Windmill Point, Virginia. Studies were conducted in the channel before dredging and during site construction as well as at specific time intervals after marsh development. This study forms a part of the Dredged Material Research Program (DMRP), Environmental Laboratory (EL), U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi, and was conducted under contracts DACW65-75-C-0051 and DACW65-76-C-0039 with the Old Dominion University Research Foundation, Old Dominion University (ODU), Norfolk, Virginia. Contracting was handled by the U. S. Army Engineer District, Norfolk (NAO); LTC R. H. Routh, CE, NAO, was the Contracting Officer.

Dr. Donald D. Adams,* Institute of Oceanography, ODU, was the principal investigator and supervised the field program and chemical studies. Dr. Dennis A. Darby, Department of Physics and Geophysical Sciences, conducted the geological and sedimentological studies, while Randolph J. Young, Institute of Oceanography, was responsible for the metals program. Dr. Robert LaBudde and J. A. Menchhoff, ODU, developed statistical routines for ANOVA and mass transport, respectively. Research assistants for this study were A. S. Katsaounis, W. T. Nivens, D. L. Stealey, and C. L. (Pomeroy) Young. Part-time help was provided by G. Adams and P. Crowley. Computer programs were developed by P. J. Anninos, J. A. Menchhoff, and L. E. Whitlock. Numerous students participated in both the field operations and laboratory analysis. The utilization of laboratory and cold room facilities at the Department of Chemistry, ODU, was greatly appreciated. Close cooperation with NAO, especially with Mr. E. E. Whitehurst, was especially helpful. The cooperation of the captain and crew of ODU's vessel LINWOOD HOLTON is gratefully

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* Present address: Department of Chemistry, Wright State University, Dayton, Ohio 45431.

acknowledged. Mr. David Harrison, Flowerdew Hundred Farm and Windmill Point Island, cooperated by allowing use of his facilities and access to the experimental site.

This work was conducted under the direction of EL personnel. The study was designed by John D. Lunz, Natural Resources Development Branch, in close cooperation with the principal investigators. The contract was managed by Mr. Lunz under the supervision of Dr. W. Gallaher, Branch Chief, and Dr. C. J. Kirby, Chief, Environmental Resources Division. The study was under the general supervision of Dr. H. K. Smith, Habitat Development Project Manager, and Dr. J. Harrison, Chief, EL. Directors of WES during the conduct of the study were COL G. H. Hilt, CE, and COL J. L. Cannon, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

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* Tables 1-25 and Figures 1-6 are in Volume I.
** Appendices A' through E' were reproduced on microfiche and are enclosed in an envelope attached inside the back cover of this volume.

HABITAT DEVELOPMENT FIELD INVESTIGATIONS
WINDMILL POINT MARSH DEVELOPMENT SITE
JAMES RIVER, VIRGINIA

APPENDIX F: ENVIRONMENTAL IMPACTS OF MARSH DEVELOPMENT WITH DREDGED MATERIAL: SEDIMENT AND WATER QUALITY

VOLUME II: SUBSTRATE AND CHEMICAL FLUX CHARACTERISTICS OF A DREDGED MATERIAL MARSH

PART I: INTRODUCTION

Background

1. In 1973 the Dredged Material Research Program (DMRP) of the U. S. Army Engineer Waterways Experiment Station (WES) was established to address environmental and technical alternatives for the disposal of dredged sediments from the Nation's waterways. One of the major programs under the DMRP was the Habitat Development Project (HDP), which was designed to evaluate and demonstrate potential fish and wildlife habitat development as a disposal alternative. Because of substantial loss of wetlands in the past decades, the major thrust of the HDP was toward the development of marshes from dredged material. Eight marsh development study locations were established throughout the United States. The Windmill Point site, located on the James River about 16 km downstream from Hopewell, Virginia, was one of these studies.

2. Shoaling on the James River has been a major problem to safe navigation and transport of cargo to the ports of Hopewell and Richmond (U. S. Army Engineer District, Norfolk 1974). As early as 1870, Congress approved the excavation of a channel between Richmond and Newport News (Pleasants 1973). Portions of the Jordan Point-Harrison Bar-Windmill Point shoal, located approximately 93 km upstream of the river's mouth and the harbor of Hampton Roads, require annual main-

tenance. Biannual dredging of approximately 222,000 m^3 from this 13-km channel and the subsequent open-water side channel disposal of the dredged material resulted in filling of the river bottom and the creation of a small 0.6-ha island south of the channel upstream from Windmill Point. The Windmill Point marsh development site, hereafter referred to as the "development site" or "artificial habitat," was established in early 1975 in shallow waters on the upstream side of this preexisting 0.6-ha island composed of dredged channel sediments.

3. The U. S. Army Engineer District, Norfolk, and the Environmental Laboratory (EL) at WES developed this artificial marsh-island complex as part of the normal maintenance dredging program of the navigational channel. Approximately 62,300 m^3 of sand was pumped from a borrow area near Buckler's Point to construct retaining dikes for the artificial marsh (Figure 1 in Volume I).* Between 21 January and 4 February 1975, approximately 166,540 m^3 channel sediments were pumped into the 6.1-ha rectangular (396 by 152-m) site (Table 1 in Volume I) to provide an average fill depth of 1.1 m. All dredged channel sediments entered the rectangular diked area at its northwest corner; the dredged material slurry traveled approximately 425 m within the dike before reaching the unrestricted effluent discharge point located at the dike's southeast corner and consisting of two 0.9-m diameter corrugated steel pipes. Following the completion of dredged material disposal activities, these effluent pipes along with a small breach that developed in the southern portion of the dike served as entry and exit locations for regular tidal influence on the experimental substrate. Before and after site development, extensive studies were conducted by the HDP to document the chemical, biological, and geological alterations related to this marsh habitat development project.

4. The objectives of studies reported in the first volume of this appendix were: (a) to document the chemical and sedimentological nature of the channel sediments before dredging, (b) to relate these findings to effluent water quality at the development site during dredging, and

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* Figures 1 to 6 and Tables 1 to 25 appear in Volume I.

(c) to document the mobilization of selected potential pollutants from the recently dredged substrate to the river water in the short term following site construction. Additional sediment and water-quality investigations were conducted at the Windmill Point development site and at a reference marsh after site construction was completed. These additional studies were designed to contrast the physical and chemical characteristics of the substrate and tidal waters at the two marshes. The results of these studies comprise the second volume of this appendix entitled, "Substrate and Chemical Flux Characteristics of a Dredged Material Marsh."

5. Field studies were undertaken eight different times at the site over a period of 2 years to investigate conditions during and after marsh development. The first six field collections were conducted at the development site only and provided the data discussed in Volume I. The last two field collections included observations at both the development site and reference marsh, situated 3.2 km upstream from the development site, near the mouth of Herring Creek at Ducking Stool Point (Figure 2 in Volume I); these data are presented in Volume II. Data interpretation emphasized the relationships between the chemistry and geology of fine-grained sediments, the change in the chemistry and geology of the sediments and river water related to a specific dredged material disposal alternative and the establishment of a freshwater marsh habitat. Results of these studies are applicable to Corps of Engineer (CE) projects requiring an understanding of: (a) the chemistry and geology of fluvial-estuarine sediments in areas of rapid desposition, and (b) the chemical budgets in freshwater marsh ecosystems.

Approach and Chronology

6. Ten sediment cores were taken along a 1.5-km section of the navigational channel of the Jordan Point-Harrison Bar-Windmill Point shoal before dredging in January 1975. The effluent from the intertidal habitat containment area was sampled every 6 hours at one of the effluent pipes during four 48-hr periods: once during dredging (31

January to 1 February 1975); again during the dewatering period (6-8 February 1975), two days after dredging had ceased; and two additional 48-hr periods on 18-20 April and 13-15 May 1975, approximately 2.5 and 3.5 months after dredging, respectively. Because of unusual weather conditions in April, when high winds prevented tidal water from entering the diked intertidal habitat, only the May sampling program will be reported. This information is provided in Volume I.

7. The last 48-hr field water-quality studies were conducted 18 (5-7 August 1976) and 24 months (8-10 January 1977) after dredging. These two programs were the most extensive of the field operations and were chosen to represent different seasons. Sediment studies were conducted by coring three different locations (subtidal, intertidal, and high marsh) at the development site on three different occasions during July 1975 (6 months after dredging), August 1976 (18 months after dredging), and January 1977 (24 months after dredging). The reference marsh was sampled at corresponding locations during August 1976 and January 1977. At each of these locations, cores were collected within a 25-m^2 quadrant for a total of nine cores from each marsh for each period (Figures 2 and 3 in Volume I). Sediments from these cores were divided into specific depth intervals of 0 to 10 cm (surface), 11 to 24 cm (mid-depth), and 25 to 50 cm (deep). In addition, surface sediment grab samples and cores were collected within the development site in July 1976 (17 months after dredging) and July 1977 (29 months after dredging) for special studies (Table 2 in Volume I, Table 26).

8. A listing of the various parameters examined throughout this study is presented in Table 2 (Volume I). Data plots for each of the parameters are presented in Appendix A'; data tabulations are presented in Appendix B'. Sediment and tidal statistics are listed in Appendix B'.

Physical Setting

9. Windmill Point is located on the James River approximately 51 km below Richmond, Virginia, and 93 km above the harbor of Hampton Roads. Slightly upstream of Windmill Point is the Jordan Point-

Harrison Bar-Windmill Point shoal located between Buckler's and Windmill Point (Figure 1 in Volume I). Portions of the channel associated with this shoal require annual maintenance dredging and experience an overall sedimentation rate in the channel of about 90 cm/yr. This specific portion of the channel was last dredged two years prior to being used for habitat development. A description of this section of the river is provided in Table 1 (Volume I). Only 16 km upstream of Windmill Point is the industrial city of Hopewell, which discharges effluent containing an average of 36,000 kg/day biochemical oxygen demand (BOD) (Diaz and Boesch 1977). Major manufacturing activities at Hopewell are chemicals, paper products, fertilizers, and synthetic fibers. Effluents from these industrial activities probably contribute to historical indications that bottom sediments near Windmill Point exceeded Environmental Protection Agency criteria for open-water disposal of dredged materials due to levels of chemical oxygen demand (COD), volatile solids, total Kjeldahl nitrogen (TKN), lead, and zinc.

10. Previous salinity data for the study area, which is part of the lower tidal freshwater James, indicated the absence of salt water during 1968 and 1969 (Brehmer 1972), yet it was suggested by Diaz and Boesch (1977), based on benthic faunal data, that during drought conditions in the mid-1960's, intrusion probably occurred as far upstream as Hopewell. Salinity typically does not exceed 2 o/oo at Swann's Point located 30 km downstream of Windmill Point. Tidal currents of 0 to 80 cm/sec, with a normal range of 20 cm/sec, were reported for a section of the James River 20 km below the study area (Nichols 1972). The mean annual river discharge was approximately 212 m^3/sec with recorded extremes of 0.3 to 9,200 m^3/sec.

Water quality

11. One of the three major BOD peaks on the James River was reported near and below Hopewell (James River Comprehensive Water Quality Management Study 1972), where oxygen depression was a common occurrence in the summer. Dissolved nitrate-N was as high as 2 mg/ℓ for the waters of the study area, while dissolved inorganic orthophosphate-P reached concentrations of 0.6 mg/ℓ during October for this stretch

of the river. Brehmer (1972) reported a mean pH of about 7.7, with a range of 6.8 to 8.6, for the freshwater section of the James River, while suspended solids concentrations ranged between 29 to 44 mg/ℓ with approximately 19 to 31 percent consisting of volatile matter (Brehmer and Haltiwanger 1966). Further data are provided in Table 3 (Volume I).

Sediment quality

12. The redox potential of the James River channel sediments ranged from -70 to +50 mV within the top 18 cm, while the interstitial pH was reported as 6.7 for two stations near the study area (Moncure and Nichols 1968). At stations below Windmill Point, these authors reported organic matter content varying between 0 and 4 percent. Analyses of channel sediments near Windmill Point indicated 10 percent volatile solids, 9 percent chemical oxygen demand (COD), 2,190 ppm total Kjeldahl nitrogen (TKN), 53 ppm lead, 0.3 ppm mercury, and 260 ppm zinc (U. S. Army Engineer District, Norfolk 1974). Other data (Lunz and Huggett 1974) gave values of 464 ppm total phosphorus, 28 ppm total copper, and 49 percent total solids. Further data are listed in Table 3 (Volume I).

13. Previous analyses of sediment particle size or cation exchange capacity have not been reported for the Windmill Point area. The lower 77-km section of the James River contains silty clay or sand, or a mixture of sand-silt-clay with an average of 39 percent clay (Moncure and Nichols 1968, Nichols 1972). These authors also reported a general decrease in sediment size sorting and water content from the estuary mouth upstream and from dredged channels to the shoals.

14. Quartz and feldspar dominated the sand-size sediment, with lesser amounts of fecal pellets, plant debris, heavy minerals, mica, coal fragments, fly ash, and cinder (Nichols 1972). Calcium carbonate contents of the sediments decreased from 41 percent at the mouth of the James River to 2 percent 77 km upstream. Nichols (1972) also reported that the clays consisted of 44 percent illite, 24 percent chlorite, 18 percent smectite, and 15 percent kaolinite in the vicinity of Hopewell, with decreasing amounts of smectite and illite downstream, while Feuillet (1976) listed 33 percent kaolinite, 30 percent mixed-

layered clays, 20 percent illite, 12 percent vermiculite, less than 5 percent chlorite, and 3 percent smectite for the same area of the river. Because clay minerology values are imprecise and normally vary by ±15 to 20 percent, the only real difference between these two reports was the identification of vermiculite and mixed-layered clays by Feuillet (1976).

PART II: CHARACTERIZATION OF SUBSTRATES AT THE JAMES RIVER ARTIFICIAL HABITAT DEVELOPMENT SITE AND A REFERENCE MARSH

Introduction

Purpose

15. Because the geological and chemical characteristics of the sediment and its interstitial water are important to plant growth and to the mobilization of contaminants, the same parameters that were measured in the James River channel sediments were monitored at both the development site and the reference marsh in August 1976 and January 1977. Comparisons of observations at the development site with those at the reference marsh allowed the identification of temporal changes unique to the contained dredged material.

Physical setting

16. The development site. Approximately 166,500 m^3 of James River channel sediments were pumped into the development site during the winter of 1975. This material flowed diagonally across the rectangular containment area (6.1 ha), and an estimated two-thirds exited through the outlet pipes forming a delta approximately half the size of the diked area. The sediment deposited inside the dike averaged about 1.1 m in thickness. Tidal flow through the pipes developed channels that extended about two-thirds the distance across the development site and paralleled the flow pattern of the dredged material slurry disposal into the containment area. A breach that occurred in the sand dike near its southeast corner (Figure 3 in Volume I) within 3 months after dredging served as a major tributary for tidal influence within the containment area. These tidal channels within the development site were 5 to 20 cm deep except at the pipes and breach. About two-thirds of the containment area was flooded by normal high tides with approximately 20,000 to 40,000 m^3 of water. Volunteer plant growth was evident in the spring of 1975 about 3 months after dredging and covered the diked substrate by July 1975. Only small clumps of dead vegetation and root systems remained during the winter months. In the first 2 years, the sand dikes

on the west, upstream side, of the site were gradually eroded, moving the highest elevation of the dike about 10 m to the east and over the edge of the dredged sediments inside.

17. The reference marsh. The tidal channels entering the reference marsh were about 2 m deep and 17 to 26 m wide. These channels formed a rectangular pattern immediately adjacent to Herring Creek (Figure 3 in Volume I) and are believed to have resulted from dike construction in the eighteenth century when rice was experimentally cultivated in this marsh. Near the center of the marsh, the tidal channels decrease in depth to less than 50 cm at low tide and become more sinuous and typical of natural tidal marshes. The reference marsh was similar to the development site in vegetation composition but was dominated by different plant species. The winter appearance of plants was similar at both sites but the reference marsh had a denser and deeper root system than was evident at the younger development site. Approximately 220,000 m^3 of water flooded the reference marsh during each tide, or about five or six times more volume than at the development site.

Methods and Materials

18. A total of 72 sediment cores and 19 surface grab samples were collected from the two marshes (Table 26 and Figures 2 and 3 in Volume I, and 7 and 8 in this volume). Cores were collected from three locations at each marsh corresponding to high marsh, intertidal, and subtidal zones for monitoring differences in values for total and interstitial dissolved metals, carbon, nutrients, sediment cation exchange capacity, sediment particle size, pH, Eh, pS, temperature, percent water, and percent volatile solids. Cores were collected from the same 25-m^2 locations at each marsh in August 1976 and January 1977 except for the intertidal and subtidal locations at the reference marsh where ice conditions blocked boat access in January 1977. This necessitated sampling near the channel banks, accessible overland, instead of midchannel locations. Cores were divided into surface (0 to 10 cm), middepth (11 to 24 cm), and deep (25 to 50 cm) horizons, except for July 1975 cores (see Appendix B' for

specific depth intervals). Analytical procedures were the same as those used for the James River channel sediment cores presented in Part II of Volume I except that most interstitial water parameters from the July 1975 cores were not analyzed for 17 to 19 months following collection, partially because of contractual delays. Interstitial ammonium and total H_2S concentrations were measured immediately after the July collection. Hydrogen sulfide was analyzed according to a modified method outlined in Goldhaber (1974). Interstitial water to be used for chemical measurements was acidified and frozen. The lengthy storage of the July 1975 collections precluded their analysis for interstitial mercury concentrations. Total calcium and chromium levels were analyzed by atomic absorption with a nitrous oxide-acetylene flame to minimize interferences; all other metals except mercury were analyzed with an air-acetylene flame. Cation exchange capacity was measured on unfractionated samples by sodium saturation and displacement by ammonium acetate (Chapman 1965) in order that results might be compared with other DMRP habitat development studies.

19. Samples for cation exchange capacity could not be analyzed immediately in all cases. A test on the effects of sealed storage in plastic bags at room temperature was made on two samples from the development site. These samples, analyzed in duplicate, decreased in cation exchange capacity by 23 $\pm$ 10 percent after storage for 13 months (Appendix B'). This decrease may have been due to a combination of organic matter decomposition and the visible formation of iron oxides and hydroxides, which could block exchange sites. Because of apparent storage effects on cation exchange capacity, values used in this report were from analyses conducted as soon as possible after collection, and at least within 6 months.

20. Possible effects of various centrifuge speeds on the concentrations of interstitial metals and nutrients were compared to concentrations obtained with a sediment squeezer (Presley et al. 1967). Significant changes in concentration were not observed with centrifugation above 9,000 and up to 15,000 rpm for 20 minutes at $4^{\circ}C$. For comparisons with centrifugation, a homogenized subsample was squeezed and fil-

tered with 100 psi (689 kilopascals) nitrogen. Dissolved calcium, manganese, and phosphate-P concentrations were slightly higher with centrifugation while iron concentrations were the same and zinc concentrations were lower than with squeezing. Dissolved nitrate and nitrite-N was higher by centrifugation; however, for the processing of numerous samples, centrifugation was the preferred procedure because of both speed and efficiency.

21. Digestion and drying procedures were also compared to determine the maximum recovery of total metals from the marsh sediments. Both oven drying at 60°C and freeze drying were tested along with acid digestions at 60°C and 95°C for 1.5 and 5 hr, respectively. Freeze-drying followed by acid digestion at 95°C for 5 hr provided the best recovery for the metals tested, with the exception of mercury, for which sediments were processed at the lower temperature. Metals associated with different fractions of the sediment were studied according to the method outlined in Engler et al. (1977).

22. Sediment samples for total water content and volatile solids content were collected in tared vials from the marsh surface adjacent to each core and from the bottom of each core. Sediment field vane shear measurements were made with a hand vane tester at depths of 23, 53, 84, 115, and 145 cm, or to depths that the vane no longer penetrated the substrate.

Results

Physical description of the marsh sediments

23. The sediment at the development site, as described from 11 split cores collected six months after deposition (Figure 7) was homogenous grayish brown silty clay with 1 to 10 percent black plant fragments (0.5 to 5 mm in dia.), 1- to 10-mm gas vesicles, and 1 to 10 percent mica flakes (0.05 to 2 mm) throughout. The dredged sediment was soupy from the surface to a depth of 10 or 20 cm. The original substrate was identified as a sharp contrast between dredged sediment and winnowed silt laminae. Below this 5- to 15-cm-thick interval of

winnowed laminae was homogenous sediment very similar to the dredged material above, but with indistinct layering. Sand layers were occasionally encountered in cores located near the sand dikes.

24. The sediment at the subtidal location in the middle of the reference marsh was similar in appearance to that of the development site. The only visible difference was occasional faint layering and mottling, the presence of plant roots in the upper 30 cm, and a greater consolidation with depth.

25. The water content values of the surface sediments 6 months after their deposition into the diked containment area were about the same as they were in the river channel (50 percent) before dredging (Table 27). In the reference marsh, the water content values were approximately 20 percent higher than those in the development site. Water content values did not change significantly at either marsh during the next 18 months. Both marshes exhibited an average decrease of 10 to 20 percent water from the surface to about a 65-cm depth.

26. While the water content did not change from the river channel sediments to the development site 6 months after deposition, the percent volatile solids at the surface (0- to 5-cm depth) decreased from 14.5 to 4.9 percent. By August 1976, following a period of luxuriant plant growth at the development site during the first summer, the volatile solids contents in the surface sediments increased to 10.9 percent (Table 27). This percentage decreased only slightly to 8.9 percent by January 1977. Percent volatile solids was higher in the reference marsh by an average of 8 percent and the change in percent volatile solids with depth was different at the two marshes. Values decreased with depth at the development site from a mean of 9.8 to 6.9 percent, while at the reference marsh there was a slight increase with depth (Appendix B'). Analysis of variance for percent water content and percent volatile solids among the three coring locations of each marsh identified differences for the surface percent water content between the different locations at both marshes and for the percent volatile solids at the coring locations of the reference marsh (Appendix B').

Chemistry of the marsh sediments

27. The sediment pH, which averaged 6.78 ± 0.35 during the first summer at the development site, was slightly higher, but not significantly different, than the James River channel (6.60 ± 0.22 pH; Table 27). This apparent difference was due to the higher pH values of 7.3 measured in the cores from the high marsh zone. Intertidal and subtidal marsh sediments averaged 6.54 in July 1975, about the same as the channel sediment. The pH changed very little during the next 1.5 years, averaging 6.41 ± 0.47 pH for the reference and artificial during August 1976 and January 1977. Also, the pH did not change substantially with depth (Appendix C') except for July 1975 cores, where the lower sections, with a higher percent water and lower pH and redox potentials as compared to the middle and upper sections of the cores, probably represented the previous substrate* before dredging. The sediments at the reference marsh were more acidic (usually by about 0.5 pH units) than those of the development site. Values for pH in the deep (25-50 cm) subtidal sediments of the reference marsh were lowest (5.3) in January 1977, and slightly more acidic than the lowest development site sediment pH value (5.8). Average pH values for both August 1976 and January 1977 were lowest (5.9) at the high marsh zone of the reference marsh; the highest average pH values (6.8) for both August 1976 and January 1977 were observed at the subtidal location of the development site.

28. Average redox potentials increased from -25 mV in the James River channel to +72 mV in the development site sediments in July 1975 (Table 27). Development site sediment Eh values continued to increase during the next 1.5 years, especially at the high marsh site where a mean of 274 ± 194 mV was observed in January 1977. Eh values at the reference marsh were also most positive in the high marsh zone (192 ± 236 mV). Redox potentials did not change appreciably with depth except

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* Depths for the lower sections of the cores collected in July 1975 were from 86 to 104 cm for two subtidal cores and 104 to 130 cm for two intertidal cores (Tables B'21 and B'22).

in the high marsh locations where the Eh values at 25 to 50 cm depth were decreased and similar to average values at the other coring sites.

29. Interstitial water chemical values in the sediments 6 months after dredged material disposal were compared with the calculated concentrations of various dissolved substances in the effluent water during active dredging. The calculations are mentioned in Part III of Volume I and are based on the assumption that effluent chemistry was influenced by the mixing of James River channel sediment interstitial water and James River overlying water (ignoring solids) in a ratio of 1 part interstitial water to 4 parts river water (Table 23 in Volume I). The dissolved orthophosphate-P concentration in the interstitial water of the development site sediments 6 months after dredging averaged 0.054 mg/ℓ, which was between the calculated orthophosphate concentration of 0.08 mg/ℓ in the effluent during dredging and the measured value of 0.030 mg/ℓ. Interstitial ammonium-N was more than twice as high (31 mg/ℓ) in July 1975 compared with the calculated value of 13 mg/ℓ. Changes in total nutrient concentrations as a result of dredging were about 25 percent: total phosphorus increased from 662 to 814 μg/g while total Kjeldahl nitrogen decreased from 4,577 to 3,376 μg/g (Table 28).

30. Dissolved orthophosphate-P composed about 50 percent of the total dissolved phosphorus (TDP) compounds in the development site and reference marsh interstitial water in January 1977 (average PO_4 = 0.06 mg/ℓ, TDP = 0.15 mg/ℓ) as it did in the channel sediments in January 1975 (average PO_4 = 0.25 mg/ℓ, TDP = 0.46 mg/ℓ). During the summer seasons this relationship decreased to between 24 and 33 percent (average PO_4 = 0.06 mg/ℓ, TDP = 0.20 mg/ℓ) with the exception of August 1976 at the development site where interstitial orthophosphate-P composed 70 percent of the total dissolved phosphorus in the sediments (average PO_4 = 0.10 mg/ℓ, TDP = 0.14 mg/ℓ). There were no appreciable seasonal changes in total dissolved phosphorus at either marsh: orthophosphate-P decreased slightly at the development site and increased from 0.06 to 0.08 mg/ℓ at the reference marsh between August 1976 and January 1977 (Table 28). Total dissolved phosphorus concentrations increased with depth in the sediment of the intertidal and subtidal zones of the development site

and subtidal zone of the reference marsh in August 1976; in January 1977 total dissolved phosphorus increased with the depth in the high and intertidal reference marsh zones.

31. Dissolved ammonium concentrations in the James River channel sediment interstitial water was 63 mg/ℓ, about 90 percent of the total dissolved nitrogen concentration (Table 28). This proportion remained nearly constant for the development site sediments 6 months after dredging even though the overall concentrations of both parameters decreased by about half. Between July 1975 and August 1976 a dramatic decrease occurred in the ratio of dissolved ammonium to total dissolved nitrogen (TDN) concentration (from 90 percent, as above, to 21 percent) as well as in the average concentrations of each parameter (Table 28). During the growing season at both marshes, the dissolved ammonium concentration was only 16 to 20 percent of the total dissolved nitrogen. This increased in the winter to 50 to 53 percent. The concentrations of both ammonium and total dissolved nitrogen were lower in the interstitial waters at the reference marsh than at the development site (Table 28). With the exception of the subtidal site at the reference marsh in August 1976, there was an increase in total dissolved nitrogen with depth at all locations regardless of the season. The same was true for dissolved ammonium with the exception of the high reference marsh zone in August 1976 and the intertidal and subtidal reference marsh zones in January 1977. Even though they were a few metres apart, cores from the intertidal and subtidal zones of the reference marsh in January were collected closer to an area that had supported denser vegetation during the previous growing season than was the case for August cores, which were collected in the middle of the small channels.

32. The interstitial concentration of dissolved nitrate plus nitrite in the sediments of the development site increased in time for an average of 0.02 to 0.11 mg/ℓ (Table 28). The seasonal changes in nitrate and nitrite were negligible at both the development site and reference marsh. During the summer, dissolved nitrate and nitrite decreased with depth in the cores at both marshes except at the high reference marsh zone where it increased. The high reference marsh zone

was also the only location at either marsh where ammonium decreased with depth during the summer and was the location with the most abundant plant growth. Depth distributions in the winter were not consistent with those of the summer. Interstitial nitrate and nitrite increased with depth at the high reference marsh zone but concentrations with depth at the other sites were almost constant.

33. Dissolved organic carbon (DOC) values at the development site were high and averaged 61 mg/ℓ in July 1975, 6 months after dredging. A comparison could not be made with the channel sediments because of the lack of data. Dissolved organic carbon decreased to 36 mg/ℓ at the development site in August 1976 (Table 28), or a change of 40 percent. January concentrations of dissolved organic carbon were only half the level of the August measurements at both the development site and the reference marsh. The overall concentrations at the reference marsh were 20 percent less than those at the development site; however, because of the variation in the data this difference was probably not significant. All of the development site zones had middepth dissolved organic carbon maxima in August, while this was the case for only the subtidal location in January. Dissolved organic carbon concentrations at the reference marsh in August 1976 decreased with depth in the high marsh and intertidal zones and increased in the subtidal zone. Depth concentration profiles in the sediments remained relatively unchanged the following January.

34. Total sediment phosphorous (TP), which averaged 662 μg/g in the James River channel, increased by 23 percent to an average concentration of 814 μg/g at the development site six months after dredging (Table 28). For the next 1.5 years,total phosphorus decreased to an average concentration of 746 μg/g during the first year and to 690 μg/g in the next six months (January 1977). Values at the reference marsh remained relatively constant between seasons and averaged 3 to 25 percent lower than at the development site. There were no consistent trends with depth in the cores during August, but in January total phosphorus concentrations usually decreased with depth in both marshes, except at the high reference marsh zone. Total Kjeldahl nitrogen, which averaged

4,577 μg/g (0.46 percent) in the channel sediments, decreased to an average concentration of 3,376 μg/g, or a 27 percent change, at the development site 6 months after dredging. Also at this time, total organic carbon measured 17,140 μg/g (1.7 percent) at the development site. Both parameters decreased substantially during the subsequent year. Total Kjeldahl nitrogen was depleted from 3,376 to 765 μg/g, while total organic carbon decreased from 1.7 to 1.0 percent (Table 28). There was a further decrease in total sediment nitrogen by about 30 percent between August and January at both the development site (from 765 to 531 μg/g) and reference marsh (from 1,540 to 1,010 μg/g). There was little difference in total organic carbon content of the sediments between the two marshes in August and January, yet total Kjeldahl nitrogen in the sediments of the reference marsh was about double the concentrations of the development site during the same time period.

35. Interstitial water metals chemistry. Sediment interstitial water calcium decreased from an average of 216 mg/ℓ in the James River channel cores to 61 mg/ℓ in the development site sediments 6 months after dredging. This value was only 13 percent above the predicted concentration of 54 mg/ℓ for mixing of channel porewater with James River water during dredging (Table 23 in Volume I). By August of 1976, dissolved calcium had reached an average level of 82 mg/ℓ, but then decreased 20 percent to 65 mg/ℓ in January 1977 (Table 29). Interstitial dissolved calcium at the reference marsh averaged 26 and 13 mg/ℓ in August 1976 and January 1977, respectively. Dissolved interstitial iron decreased from values of 57 mg/ℓ in the James River channel to 24 mg/ℓ at the development site in July 1975. This was about double the predicted concentrations during dredging (Table 23 in Volume I), which suggested solubilization of precipitated iron within the sediments of the development site shortly after filling and consolidation. In August 1976, dissolved interstitial iron concentrations averaged 31 mg/ℓ, an increase of 30 percent over the previous summer. This value decreased to 21 mg/ℓ in January 1977. Interstitial dissolved iron in the reference marsh sediments averaged 34 and 12 mg/ℓ in August 1976 and January 1977, respectively, or about a fourth of the channel sediment porewater concen-

trations during similar seasons (Table 29). Concentration trends of dissolved manganese were similar to those observed for interstitial calcium and iron. A decrease from 6.9 to 2.7 mg/ℓ, or 61 percent, occurred from the James River channel sediment values to those at the development site 6 months later. As with iron, this was about double the predicted concentrations, which again suggested solution of solid phases within the recently deposited dredged sediments. Manganese concentrations then increased by 42 percent to 3.8 mg/ℓ in August 1976, and decreased by 26 percent to 2.8 mg/ℓ in January 1977. Interstitial dissolved Mn averaged 1.4 mg/ℓ at the reference marsh in August 1976 and January 1977, or about a fifth of the mean channel sediment interstitial water concentration during the same season. Dissolved zinc increased from 0.12 mg/ℓ* in the channel sediment interstitial water to 0.32 mg/ℓ during July 1975 in the artificial marsh sediment porewater (Table 29). These concentrations for the development site interstitial waters in July 1975 were four to five times greater than predicted concentrations during dredging (Table 23 in Volume I), which indicated mobilization as had occurred during dredging. By August 1976 the interstitial water concentration of dissolved zinc at the development site averaged 0.06 mg/ℓ, a sizeable decrease from 0.32 mg/ℓ during the previous summer. These concentrations remained through January 1977. At the reference marsh, interstitial dissolved zinc was 0.08 and 0.05 mg/ℓ for August 1976 and January 1977, respectively. These levels were about half of the mean James River channel concentrations.

36. In summary, dissolved calcium, iron, and manganese exhibited similar interstitial water concentration patterns of large decreases (60 to 70 percent) following dredged material disposal into the development site; 30 to 40 percent increases from July 1975 to August 1976; and slightly lower decreases (20 to 30 percent) from August 1976 to January 1977. Zinc concentrations in the interstitial water increased during dredging, then decreased by approximately 80 percent from July 1975 to August 1976 to negligible concentrations and remained at these

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* Three values greater than 1 part per million were rejected as not being representative.

levels from August 1976 to January 1977. At the reference marsh, dissolved interstitial calcium and manganese were lower than at the development site during both August 1976 and January 1977, while interstitial dissolved iron and zinc were approximately equal at the two marshes during the summer. The apparent decrease in interstitial dissolved calcium and iron from August to January seemed to be greater at the reference marsh than at the development site. Dissolved zinc at the development site and manganese and zinc at the reference marsh did not appear to change appreciably from August 1976 to January 1977.

37. Interstitial dissolved cadmium, nickel, and lead were detected only in the James River channel sediments and averaged 0.009 mg/ℓ, 0.054 mg/ℓ, and 0.077 mg/ℓ, respectively (Table 8 in Volume I). Analyses of interstitial water collected from the development site in July 1975 suggested that the mixing of the dredged material with James River water lowered concentrations of these three metals to below the detection limits. Dissolved copper concentrations averaged 0.010 mg/ℓ in the interstitial water of the channel sediments but were not analyzed at the development site in July 1975 due to insufficient sample volume. This metal was lower at the development site than at the reference marsh in August 1976 and was below detection at both marshes in January 1977. Dissolved chromium was not included in the analysis scheme until after July 1975 and was detected only in the August 1976 sediment porewater at both marshes (Table 29). Interstitial mercury from the channel sediment cores averaged 3.2 μg/ℓ. Data were not available for July 1975. In August 1976, interstitial mercury concentrations averaged 5.6 μg/ℓ at the development site and 4.0 μg/ℓ at the reference marsh. By January 1977, mercury levels had sharply decreased to 0.8 μg/ℓ at the development site and 0.6 μg/ℓ at the reference marsh. Thus, both dissolved copper and mercury were more abundant in August 1976 at both marshes than in the channel sediments, while winter conditions resulted in their depletion in the marsh sediment porewater.

38 . Total sediment metals chemistry. The descending order of total sediment concentrations in both marshes was as follows: Fe >> Ca >> Mn >> Zn >> Pb > Cr > Cu > Ni >> Cd > Hg. Iron had the highest

concentration of all metals measured for every time period, ranging from a minimum average of 3.4 percent dry weight in August 1976 at the development site to 4.1 percent in the channel sediment cores (Table 30). Total sediment metals concentrations were slightly higher in the channel sediments than in the development site in July 1975 except for nickel concentrations, which were nearly the same, and cadmium, which was slightly higher at the development site. Following dredged material disposal in the development site, total iron, calcium, zinc, lead, nickel, and cadmium decreased insignificantly from July 1975 to August 1976 followed by a minor increase in January 1977. No change was detected after July 1975 in total sediment manganese, calcium, and mercury at the development site. Chromium continued to decrease slightly after deposition in the development site. The total metals concentration in the reference marsh sediments were similar to those at the development site except for manganese, which was about one-third the average development site value. Contrary to the development site trend of a slight increase in iron, calcium, and zinc from August to January, these metals decreased slightly at the reference marsh (Table 30), but it should be noted that this could have been a result of a slight shift in coring stations from the subtidal reference marsh zone at midchannel in the summer to a location adjacent to the channel banks in the winter.

39. Mean total sediment calcium values were consistently about one-tenth those of iron in both marshes (Table 30). Total sediment manganese averaged 1100 μg/g in the channel cores, was 900 μg/g within the development site in July 1975, and remained relatively constant thereafter. Total zinc also decreased by 20 percent between the James River channel sediments to the sediments of the development site 6 months after dredging. There was little change thereafter (Table 30); but where manganese values were lower in the reference marsh, zinc was slightly higher and decreased by January 1977 to nearly the same concentration that was found in the development site during July 1975 (190 μg/g). Total sediment lead concentrations remained unchanged and nearly the same for both marshes. Total sediment chromium levels were essentially equal in the two marshes in August 1976 and January 1977.

During this interval (August to January), chromium decreased by one-third to 40 μg/g at both marshes, which, with the exception of total calcium at the reference marsh, represented the greatest change for any total metal concentration measured during both seasons. Total copper concentrations were essentially the same in both marshes with the highest mean value in August 1976 at the reference marsh (Table 30). Total nickel and cadmium did not show any pattern of change in concentration from the channel sediments to the development site and remained relatively constant throughout. Nickel concentrations at the reference marsh (40 μg/g) were 23 - 32 percent higher than at the development site (31 μg/g). At the reference marsh, cadmium concentrations were slightly lower for both the August 1976 and the January 1977 sampling periods as compared to the development site. Total sediment mercury had the lowest concentrations of any metal measured, averaging 0.2 to 0.5 μg/g for the entire sediment sampling program.

Geology of the marsh sediments

40. Comparison of the size parameters for the development site and reference marsh indicated the following:

- a The mean sediment size for all samples in the reference marsh (8.97 Φ or 2 μm) was significantly finer than the mean sediment size for the dredged material at the development site (7.56 Φ or 5 μm).
- b Sediments from both marshes were very poorly sorted.
- c Reference marsh sediments were slightly skewed towards the coarser sizes (-0.15 ± 0.05) while the development site sediments were slightly skewed towards the finer sizes (0.15 ± 0.14). This difference was statistically significant.
- d The 6 or 7 percent sand fraction was not significantly different between the two marshes.
- e The silt/clay ratio was significantly different between the reference marsh (0.55) and development site sediments (1.24).
- f The strongest mode at the reference marsh was also significantly finer (6.80 Φ or 9 μm) than the strongest mode of the sediments from the development site (5.34 Φ or 24 μm).

g The second strongest mode for the size distributions at either marsh was not significantly different (Table 31). Similar sediment size distributions were collected from the James River channel, the development site, and the suspended material leaving the development site during dredging in January 1975. The reference marsh and tidally suspended sediments at the development site in May 1975 (3.5 months after dredging) were finer, more coarsely skewed, and contained more clay than the above three sampling locations or periods (Table 31).

41. Generally, the same clay minerals identified in the reference marsh and development site were also found in the river channel except that the high exchange capacity clays, vermiculate and smectite, were absent in the development site two years after it was created (based on only two samples; Table 32). The river channel and reference marsh sediments had about the same general proportion of clay mineral types as Tertiary age sediments in nearby cliffs along the river. The heavy minerals in the sand fraction from the reference marsh and artificial marsh were also different in relative abundance but both contained the same varieties (Table 33). The largest differences were mostly in the abundance of magnetite, tourmaline, staurolite, epidote, hornblende, and opaques.

42. Total sediment cation exchange capacity was significantly different between the reference marsh and development site in both the 0- to 10-cm and 25- to 50-cm depth intervals. The reference marsh cation exchange capacity averaged about twice that of the development site, where the mean cation exchange capacity in the surface sediments was 32.9 meq/100 g (Table 34). This difference in cation exchange capacity between the two marshes could be predicted from the clay mineral abundance using average exchange capacity values for each mineral listed in Table 32. The exchange capacity in the surface 0- to 10-cm-sediments at the reference high marsh zone was consistently higher by about 38 meq/100 g than either the intertidal or subtidal zones. The corresponding high marsh location at the development site was consistently lower in cation exchange capacity than either the intertidal or subtidal zones by about 18 to 40 meq/100 g depending on the amount of sand

in the sample (Table 34). Seasonal changes in cation exchange capacity between August 1976 and January 1977 were negligible at both marshes. Because analytical techniques were different for exchange capacity measurements of the river channel sediments and marshes, direct comparisons were difficult. Special tests on selected development site samples indicated that the exchange capacity measured as CaEC on the less than 2-μm freeze-dried fraction was about the same as the cation exchange capacity for the river channel sediments analyzed by the same technique (Table 35 and Appendix B'). Between July 1975 and June 1977, the change in cation exchange capacity was monitored for selected samples from the development site (Table 36). Although no significant change in exchange capacity occurred, the values measured in July and August 1976 were consistently higher than the earlier or later measurements.

43. The horizontal distribution of cation exchange capacity in the surface sediments of the development site during July 1976 indicated that the sediment closest to the tidal channels within the containment area were significantly lower as compared to sediment at the higher elevations (Figure 8). The average exchange capacity near the channels was 36.6 meq/100 g, while a mean of 43.0 meq/100 g was observed for the rest of the development site. The mean size, percent clay or volatile solids for the sediments were not significantly different between these two areas at the development site.

44. Organic matter and iron coatings contributed about twice as much to the total cation exchange capacity in January 1977 than in previous periods (Table 37). But January 1977 sediments were analyzed three to four months sooner than were collections from the earlier sampling periods. There was no significant difference in exchange capacity between the less than 62-μm fraction and the total sediment sample, as shown in Table 35. Organic matter exhibited a greater contribution to the exchange capacity than iron coatings, and the exchange capacity of sediments from both marshes in January 1977 were reduced by about 60 percent with the removal of organic matter.

45. Although the mean cation exchange capacity was approximately 32 meq/100 g at the development site and 60 meq/100 g at the reference

marsh (Table 34), the effective cation exchange capacity, as determined by base exchange for the nine metals measured during this program, was only about 7.1 meq/100 g at the development site and 9.4 meq/100 g at the reference marsh (Tables 38 and 39). In addition, sediments from intertidal and subtidal zones at the development site were analyzed for exchangeable magnesium, ammonium, potassium, and sodium, which averaged 1.9, 0.5, 0.13, and 0.6 meq/100 g, respectively. The mean sum of the exchangeable cations was about 10 meq/100 g, or about 25 percent of the total cation exchange capacity. Of other important cations known to occupy exchange sites, only aluminum and hydrogen were not measured.

46. The shear strength of the reference marsh sediments in August 1976 was consistently 37 percent higher than at the development site at all depths in July 1975 (Table 40). Shear strengths increased from summer to winter by approximately 46 percent at the development site and 39 percent at the reference marsh. Winter values at the reference marsh were only 26 percent higher than at the development site. As expected, there was a strong negative correlation (-0.82) between vane shear strength and water content at the reference marsh, but the correlation at the development site was only -0.58 (Table 40).

Discussion

47. The lower concentrations of dissolved nutrients and metals in the sediment interstitial waters from the development site collected 6 months after dredging, as compared to the James River channel sediment interstitial concentrations, were probably due primarily to dilution with James River water during dredging. Dissolved iron and orthophosphate-P concentrations were possibly reduced because of coprecipitation resulting from more oxidized conditions during dredging and disposal. Assuming that the interstitial water at the development site was the entrapped effluent water during dredging, then the slight increase in dissolved iron and manganese during the intervening 6-month period could be accounted for by dissolution of less than one percent of the total sediment metals or even less than one percent of the metals absorbed on the sediment

surfaces with the exception of iron. Some increase in dissolved iron concentration, and possibly manganese concentration, may have come from the easily reducible phases (predominantly as manganese oxides and hydroxides) or dissolution of iron oxides because of changes in redox potential and possibly pH in the development site sediments compared to conditions during the dredging period. The decrease in both sediment pH and Eh therefore may have accounted for the slight increase in the interstitial metals concentrations in July 1975, 6 months after dredging. Because the redox potential at the development site was never as low as the values measured in the river channel sediments, dissolved metals and nutrients at the development site remained below their former concentrations in the channel.

48. Regardless of any changes in the dissolved components from the James River channel sediments to those at the development site, the total metal concentrations remained relatively unchanged during dredging except for possible slight decreases in calcium, manganese, and zinc. Total sediment nitrogen content also decreased slightly while phosphorus increased. Minor changes were due to the higher total sediment concentrations relative to the dissolved components. If all dissolved metals had precipitated during or shortly after dredging, the total sediment concentrations would not have increased significantly (Table 41). Although volatile solids decreased dramatically from the channel sediments (14.5 percent) to the development site (4.9 percent), total metals concentrations were not significantly affected because apparently no more than 12 percent were associated with the organic phase (Table 38). Most of the loss in volatile solids from the sediment was probably due to the removal of plant debris by flotation, which was observed during dredging. Based on the percentage of metals in the organic phase of the sediments, only about half of the slight but insignificant loss in the concentrations of total sediment lead, copper, and zinc, and even less than half of any possible depletion, if it had occurred, in other total metals could have been accounted for by this decrease in volatile solids. The loss of volatile solids apparently had little effect on the exchange capacity of the channel and the development site sediments

despite the usually high contribution to exchange capacity by organic matter as noted for similar sediments (Schneitzer 1965 and Rashid 1969). Either the loss in volatile solids was due to mostly large, but low exchange capacity plant debris, or the channel sediment cation exchange capacity was due mainly to inorganic species rather than organic matter. This problem was not resolved because of analytical problems associated with the determination of organic cation exchange capacity by H_2O_2 treatment, as discussed in Part III of Volume I.

49. Even though dredging resulted in the dilution of interstitial chemical components with overlying river water, this mixing process resulted in only a few noticeable significant differences between interstitial chemical concentrations at the development site and a nearby reference marsh. Only calcium and manganese were different. Calcium concentrations were three times higher in the interstitial waters of the development site because more calcium was probably absorbed onto exchange sites at the reference marsh where the sediment cation exchange capacity was twice that measured at the development site. Calcium was the most abundant cation associated with the exchangeable phase of the sediments. It also behaved conservatively during the dredging and settlement period, where the predicted concentration of 54 mg/ℓ was only 13 to 17 percent less than the measured value at the effluent pipe during dredging (63 mg/ℓ) and in the interstitial water 6 months later (61 mg/ℓ). Interstitial dissolved manganese concentrations were about twice as high at the development site because the total sediment concentrations were about three times higher than at the reference marsh.

50. There were several other differences between the development site and the reference marsh, such as total Kjeldahl nitrogen, cation exchange capacity, sediment size, percent water, percent volatile solids, percentages of various heavy minerals, clay mineral content, redox potential, and pH. Because the total sediment and interstitial water concentrations at the two marshes were similar for many of the other metals and nutrients, the sediment cation exchange capacity was probably one of the most important factors in determining the concentration of dissolved calcium, the most abundant interstitial cation.

Also, variations in sediment size, minerology, volatile solids, Eh, and pH were probably not important enough to cause statistically significant differences between the two marshes with respect to most of the total or interstitial water chemical parameters. Apparently the sediments and water at both marshes had common sources and the differences between the two marshes were mainly a result of the depositional process that formed them as well as differences in physical setting and age. Obviously, the reference marsh was not formed by rapid deposition of homogenized sediments from a short section of the river channel and was not surrounded by sand dikes like the development site. Because they were most likely deposition from tidal currents and not a dredged slurry, the reference marsh sediments were finer grained and contained slightly different mineral abundances as compared to the development site. This concept was supported by the similarity in sediment size distribution at the reference marsh and the tidally suspended material at the development site (Table 31). The depositional processes in the river channel, which had the same sediment size distribution as at the development site, were most likely different than those at the reference marsh where tidal currents were much slower. Therefore, the similarity of heavy minerals at the two marshes suggested a common source of sediments, while differences in heavy mineral percentages were due mainly to the location of the reference marsh, and its slower currents, relative to the river channel from which the development site sediments were obtained. Besides the difference in sediment size distributions at the two marshes, slight differences in clay mineralogy and initial low volatile solids content at the development site were probably due to the different depositional processes that formed each marsh. Because of their small size and disc shape, smectite and vermiculite (two minerals with high cation exchange capacity values) were apparently floated out of the development site during or shortly after dredging along with most of the plant debris and other organic matter.

51. The older age of the reference marsh could possibly account for its lower total manganese and pH and higher total Kjeldahl nitrogen, volatile solids, and sediment shear strength values. Solid manganese

apparently was slowly solubilized below the marsh surface,with the result that dissolved manganese migrated upwards and was eventually lost to the overlying tidal waters. As shown in Part III of this volume, dissolved manganese was exported and particulate manganese imported at both marshes during August and January. The rate of net export was 17 times higher in the summer at the reference marsh as compared to the winter, while there was a difference of four at the development site. This suggested that bioturbation rather than diffusion was the dominant mechanism for transfer of manganese from the sediments. Concentrations of several total sediment metals (cadmium, calcium, copper, lead, and zinc) suggested a depletion with depth in the reference marsh sediments, which was not always the case for the development site (Table 42). If it is assumed that both marshes had similar sources as indicated above, and thus the same original total metal concentration, approximately two-thirds of the total manganese at the reference marsh was lost by such dissolution processes. This, however, did not seem to be the case for the other total metals. Higher volatile solids and total Kjeldahl nitrogen at the reference marsh were probably due to the accumulation and decomposition of plant debris and other types of organic matter over a long period of time. Such processes are known to lower pH and increase the total nitrogen content of the sediments (Black 1968 and Bolt and Bruggenwert 1976). This created an environment with a mean pH about 0.5 units lower than at the development site, which certainly aided in the solubilization of manganese. The pH may have been buffered by the sediment cation exchange capacity, where up to 75 percent of the exchange capacity could have been occupied by hydrogen ions as was suspected for estuarine sediments in the nearby Rappahanock River (Nelson 1962). This buffering or selective H^+ adsorption may effectively prevent the depression of pH in freshwater marshes as well as estuarine sediments. Bolt and Bruggenwert (1976) noted that hydrogen ions have a highly selective association with organic ligands and oxide surfaces and that addition of a neutral electrolyte was needed to decrease pH. The downward percolation of rain water, a nearly neutral electrolyte, through the high marsh zone of the development site

probably resulted in a greater lowering of pH with time. At least this was more important than the oxidation of iron, which occurred to a greater extent in the high marsh zone and would increase pH levels (Singer 1977).

52. Well-developed root systems, which were especially noticeable in the high marsh zone of the reference marsh, accounted for some of the greater sediment shear strength at the reference marsh. Slow compaction over more than 200 years would also be an important factor. If greater compaction along were the cause of higher shear strength, the reference marsh should have lower instead of higher water content than that at the development site. Because total manganese (and thus dissolved manganese), volatile solids, pH, total Kjeldahl nitrogen, and shear strength differed between the two marshes as a result of age differences, in the future these parameters at the artificial marsh should approach values measured at the reference marsh.

53. Another difference between the development site and reference marsh, which may have been due to their modes of formation and physical setting, was the variability among sampling sites. Excluding the sandy high marsh area at the development site, there was less of a difference between the other two development site locations than existed between sampling sites at the reference marsh. This was especially noticeable for redox potential, total Kjeldahl nitrogen, dissolved nitrate and nitrite, dissolved total nitrogen, dissolved ammonium, total sediment phosphorus, volatile solids, cation exchange capacity, and sediment particle size, which varied more between sites at the reference marsh than between the intertidal and subtidal locations at the development site (Appendix C'). The greatest variation at the reference marsh occurred between the high marsh zone and the other two locations. Also, there was a greater variation between the intertidal and subtidal zones at the reference marsh as compared to similar locations at the devleopment site. Obviously, the close resemblance in physical setting for the subtidal and intertidal coring locations at the development site was responsible for the similarity in nearly all measured parameters at these locations. The intertidal zone at the

reference marsh contained much more plant growth as compared to the subtidal zone. This location could have been part of an old dike built during colonial times, which would also explain this site's greater vane shear strength. Although the high marsh sites at both marshes contained the most sand, because of the nearby dikes, the high marsh at the development site had more than twice the sand that existed in the high zone of the reference marsh. This location at the reference marsh also contained the greater density of marsh plants compared with the other two locations. The subtidal reference zone was located in the middle of an unvegetated tidal channel in the summer. The winter subtidal reference sampling location was situated near tidal channel banks adjacent to an area of relatively dense plant growth and within about 2 to 3 m of the previous summer's location. Thus, much of the variability among sampling locations at the reference marsh was due to the choice of different physical settings.

54. Because variations among replicates were large (Tables 28 to 30) for most parameters, only very large differences at the development site from July 1975 to August 1976 were probably statistically significant. Total dissolved phosphorous and nitrogen, dissolved ammonium, dissolved organic carbon, total Kjeldahl nitrogen, total sediment phosphorus, and total organic carbon all decreased sharply at the development site, possibly as a result of increased plant growth during the second summer and higher rates of aerobic microbial activity as compared to the anaerobic conditions in the channel. The change in total sediment phosphorus was not as noticeable as with the other parameters, probably because of precipitation of dissolved phosphate with ferric iron in the surface sediments. This would not be the case for the end-products of organic nitrogen and carbon decomposition, which could eventually be lost to the atmosphere (as N_2O, N_2, or CO_2) or to the overlying tidal waters. Only dissolved orthophosphate-P and nitrates plus nitrites increased during the period from July 1975 to August 1976. Bacterial nitrification under oxidizing redox conditions in the sediment surface zone and burrow holes of organisms certainly aided in creating the higher levels of dissolved nitrates and nitrites.

Perhaps aerobic bacterial decomposition of some of the abundant dissolved phosphorus compounds (0.22 mg/ℓ) in July 1975 to about half this concentration by August 1976 released a greater amount of interstitial dissolved phosphate than would normally be present during the growing season. The lack of vertical gradients with depth in the sediments at either marsh for total dissolved phosphorus and dissolved orthophosphate-P suggested that plant utilization and perhaps burrowing organisms aided in homogenizing these sediments within the upper 50 cm. The lack of distinct sediment laminations also supported physical mixing. Total nitrogen, on the other hand, decomposed to dissolved organic and inorganic compounds faster than these components were utilized by plants or lost to the overlying waters by mixing and diffusion processes, therefore increased concentrations with depth in the sediments were observed. Dissolved ammonium increased with depth at all locations except at the high and intertidal reference marsh zones where vegetation was denser in the summer. Plant roots may have utilized and depleted dissolved ammonium down to the 50-cm depth at these two sites. The difference between the depletion of dissolved ammonium and orthophosphate-P in the surface 50 cm was probably enhanced by the greater solution mobility of the former and the higher absorptivity of phosphate onto sediments (Black 1968) as well as precipitation of orthophosphate with oxidized forms of iron in sediment borrows created by organisms and spaces around plant roots.

55. The difference in total Kjeldahl nitrogen between the channel sediments and the development site suggested that these organic materials were easily decomposable and that the nitrogen components were rapidly mineralized under such subaerial conditions. Because higher rates of nitrogen as compared to carbon decomposition were reported for organic detritus in lake water (Koyama and Tomino 1967) and opposite results were reported for leaf mineralization in hard water systems (Wetzel and Manny 1972), decomposition of organic matter at the development site apparently depended on the type of material as well as the bacterial population. Nitrification in the surface 0 to 10 cm could lead to a significant loss of soil nitrogen (Keeney 1972 and Serruya

et al. 1975), while denitrification in the waterlogged, oxygen deficient sediments below the surface could result in further losses through N_2O and N_2 protection. The soluble products of total Kjeldahl nitrogen mineralization (i.e., total dissolved nitrogen and ammonium) would accumulate in the deeper sediments. These components would be mixed into the surface through bioturbation and methane degrassing where oxidation and/or subsequent losses to the overlying tidal waters would occur. High mineralization rates of total Kjeldahl nitrogen were substantiated by the increased concentrations of total dissolved nitrogen and ammonium with depth in the sediments at all of the development site zones during both seasons (Appendix C') and the sizeable net mass export of total dissolved nitrogen compounds (8.7 kg/tidal cycle) during August 1976 (Part III of this volume). This was not the case for orthophosphate-P and dissolved total phosphorus. The continual loss of sediment Kjeldahl nitrogen as dissolved components at the development site (Table 43) could eventually produce a nitrogen deficient system requiring substantial nitrogen subsidy, such as bacterial nitrogen fixation, for future plant growth (Brooks et al. 1971).

56. With the exception of total Kjeldahl nitrogen, nutrient depletion due to diffusion, bioturbation, or plant utilization, balanced by enrichment from the decomposition of total nutrients, seemed to attain equilibrium conditions at the development site within two years (Table 28). By August 1976, dissolved and total nutrients at the development site were nearly the same as those at the reference marsh. Only total Kjeldahl nitrogen remained at a significantly lower level at the development site; this condition occurred very rapidly during the first one and one-half years after dredging and disposal operations. This assumed, of course, that the reference marsh was at or near equilibrium with respect to the balance between plant productivity and the bacterial regeneration of nutrients and that the concentrations of total sediment and interstitual water components would reflect such relationships. Because of its age the reference marsh should probably be close to equilibrium, although this investigation did not represent a long enough period of data collection to confirm such a hypothesis. Recent changes such as nearby dredging activities, applications of pesticides and fertilizers on adjacent fields,

and the unusual introduction of Kepone just upstream of this site could have altered the natural processes toward equilibrium, yet there were no data to confirm or reject this possibility.

57. The slightly higher concentrations of sediment interstitial calcium, iron, and manganese at the development site from July 1975 to August 1976 were probably due to the mobilization of these ions from the easily reducible phase, especially in the intertidal and subtidal development site zones where greater plant growth and tidal mixing may have depleted near surface (0 to 10 cm) concentrations. It is suspected that the precipitates of iron and manganese that were formed during dredging due to the rapid changes in redox conditions were relatively unstable and could be solubilized once deposition and consolidation of the sediments within the diked containment area occurred. Conditions would then be more favorable (i.e., a lowering of redox and perhaps pH) for their solubilization. Even though there was an increase in sediment concentrations of dissolved calcium, the mechanisms were not clear since the budget calculations (Table 23 in Volume I) did not suggest precipitation of calcium during dredging. These subtle changes during this 13-month interval were probably not statistically significant due to the large variability in the data (Table 29). Monitoring of the two marshes during a longer time period would provide a better understanding concerning trends in dissolved calcium, manganese, and iron at the development site. Interstitial zinc concentrations decreased significantly from July 1975 to August 1976 at the development site (Table 29). Even though Lee et al. (1976) did not report a substantial uptake of zinc by two freshwater marsh plants, nevertheless studies at the development site suggested that the reduction in zinc at this marsh was related to plant growth, because most of the decrease in zinc concentration occurred in the intertidal and subtidal development site zones where abundant vegetation was evident. Sample contamination as evidenced by the high variability in the measurements of zinc was also a possibility (Subramanian et al. 1978) since sample containers were not cleaned according to the method outlined in Moody and Lindstrom (1977). This would account for some of the variability in the data but not for the depletion in inter-

stitial zinc concentrations at the development site during the 13-month interval. Significant changes were not evident with respect to the total metals during this time interval, but for this to have occurred abnormally high rates of weathering would have been required.

58. Although the surface sediment cation exchange capacity near the tidal channels at the southeast corner of the development site were approximately 7 meq/100 g lower than values for the rest of the development site during July 1976, other parameters were not significantly different between these two areas. If this change had occurred since the time of original deposition, resuspension and removal of finer, high exchange capacity clay minerals and colloids due to tidal action within and adjacent to the channels near the two entrances to the development site could have explained such losses. Because a survey of cation exchange capacity over the entire marsh prior to July 1976 had not been conducted, it is suggested that the lower surface values were due to the winnowing of these minerals and colloids during initial deposition.

59. The average 24° C drop in mean temperature from summer to winter may have caused a decrease in the concentration of dissolved metals in the sediments at both marshes (Table 29) because of the lowering of solubility with decreasing temperature. This was reported (Florence 1977) for the labile forms (measured as ionic species by anodic stripping voltometry) of copper and lead in natural water samples. Such would not have been the case for dissolved calcium, which should have increased when the temperature was depressed. The lowering of temperature may also have caused a decrease in interstitial dissolved organic carbon (Table 28) by promoting polmerization and precipitation of organic compounds in the winter (Akiyama 1973). Freezing has been used as a method for concentrating organic matter dissolved in water samples (Baker 1967), and therefore could have coprecipitated chelated and complexed metals. Even though Katsaounis (1977) found no correlation between interstitial dissolved organic carbon and dissolved mercury at the two marshes, this process was probably more important for the major dissolved metals than changes in solubility product constants because a greater decrease in dissolved metals was indicated at the

high marsh zones at both marshes where most of the depletion in interstitial dissolved organic carbon also occurred (Appendix C').

60. The overall increase in levels of dissolved ammonium in the sediments during the winter at both marshes was probably due to a lack of plant utilization during the winter as well as higher nitrification within the sediments during the summer as a result of higher evaporation demand leading to more oxygen diffusion into the sediments, higher levels of bacterial activity, and increased mixing of the sediments by organisms (bioturbation). Dissolved ammonium decreased in the sediments at the subtidal coring location at the reference marsh between August 1976 and January 1977; this was probably due to the change in sampling from mid-channel in the summer to a location adjacent to the bank of the channel in the winter. Thus, winter cores from the subtidal zone of the reference marsh were collected from marsh sediments depleted in pore water ammonium by plant uptake during the previous summer. The pore water ammonium:total dissolved nitrogen ratio also changed from 1:4 to 1:6 during the summer to 1:2 in the winter primarily as a result of a larger net export of total dissolved nitrogen from the subtidal and intertidal zones of both marshes. As shown in Part III of this volume, this was the case for total dissolved nitrogen during the summer at the development site and during the winter at the reference marsh; if these net transport values are indicative of the yearly warm and cold climatic conditions, the overall transport of dissolved nitrogen compounds at both marshes would be a net export of about 6 kg/tidal cycle at the development site and 11 kg/tidal cycle at the reference marsh (similar calculations for dissolved ammonium were much lower, or net exports of 0.1 and 1.5 kg/tidal cycle, respectively). This was not the case at the high marsh sites where there were no significant differences in total dissolved nitrogen between the two seasons. The pore water of the two high marsh locations were both relatively low in total dissolved nitrogen compounds during the summer, but probably for different reasons. Rain percolation and dilution probably caused low values in the sandy sediments of the high marsh zone at the development site, while plant utilization or substantial aerobic decomposition resulted in low

total dissolved nitrogen concentrations, which decreased toward the surface, in the high marsh zone at the reference site.

61. The slight decrease in interstitial concentrations of orthophosphate-P from summer to winter at the development site may have been due to higher than normal August 1976 values (normal being defined by the reference marsh values). Winter values at both marshes were about the same, but summer values of total sediment phosphorus were somewhat higher at the development site. Aerobic decomposition and solubilization of some of the total sediment phosphorus could have caused higher levels of interstitial orthophosphate at the development site in August.

62. Except for total dissolved phosphorus and orthophosphate-P, total organic carbon, and possibly dissolved zinc, all chemical parameters had similar changes from summer to winter at both marshes. Pore water total dissolved phosphorus and orthophosphate-P as well as total organic carbon were similar at both marshes by January 1977. There may be a more uniform change in the future if the different seasonal changes, which were measured during the 1976-77 sampling period, were primarily due to the unusual August 1976 concentrations. Thus, although most nutrient levels were high at the development site in July 1975, or shortly after dredging, these levels decreased by January 1977 and approached concentrations observed at the reference marsh. Only sediment total Kjeldahl nitrogen remained significantly different after two years at the development site, where values were about half those at the reference marsh. Most of this difference in the mean total Kjeldahl nitrogen concentrations were due to the extremely low values in samples collected from the high marsh zone (215 μg/g) of the development site in January 1977. These low values could have been due to subsurface oxidative decomposition of nitrogen under consistently higher redox levels and the loss of ammonium and total dissolved nitrogen by dilution with percolating rain water or river water during higher than normal tides.

63. The only total sediment metal concentration that was significantly different from summer to winter was chromium, which decreased from 63 to 40 μg/g at both marshes (Table 30). The cause for this

change has not been resolved, but sediments at all depths at the high marsh locations at both marshes were reduced in total chromium concentrations relative to lower marsh sampling locations (Appendix C').

PART III: CHEMICAL FLUX CHARACTERISTICS OF A DREDGED MATERIAL MARSH AND A NATURAL MARSH

Introduction

Purpose

64. In order to assess the mobilization of contaminants at the artificial habitat, the tidal entrances to this marsh (Figure 3 in Volume I) and a natural reference marsh located 3.5-km upstream (Figures 1 and 2 in Volume I) were monitored during one summer and one winter over a 48- to 52-hour interval. This assessment involved the calculation of mass fluxes from concentration and volume data so that net gains or losses at the dredged material and natural marshes could be determined and compared.

65. Approximately 40,000 m^3 of tidal water usually entered the development site through two 0.91-m diameter pipes and a natural breach with a maximum cross-sectional area of 2.16 m^2 in August 1976 and 3.12 m^2 in January 1977 (Figure 9). During low tide the breach was dry while tidal water continued to flow through the pipes. In fact, water continued to drain from within the dike during the last portion of the ebb tide when the water level was below the elevation of nearly all of the sediment surface. This phase of the sampling period was termed pore-water drainage (PWD). When the ebb flow at the breach ceased, current velocities at the pipe increased (Figure 10). Sediments around the breach were composed primarily of sand derived from the dike while fine sand to clay dominated the exterior and interior channels leading to the pipes. In fact, in August 1976, dry sand was lifted by the flooding tide and rafted into the interior of the dike at the breach as part of a surface film. While sand from the dike formed a thin deposit over the dredged muds and extended 30 m inside the development site at the breach, a large delta of fine-grained sediments was formed outside of the development site at the pipes. These fine sediments were partially resuspended by the flood currents, which, because of winnowing, resulted in a less than 3-cm thick layer of very fine sand over the delta.

66. Tidal currents at the development site (50 to 60 cm/sec) were frequently 5 to 7 times greater than those measured at the large channel of the reference marsh (8 to 10 cm/sec). Using an average tidal period of 12.42 hours, tidal height of 0.71 m (Table 1 in Volume I), and tidal volumes of 30,000 m^3 at the development site and 220,000 m^3 at the reference marsh, average current velocities calculated from cross-sectional areas given in Figures 9 and 11 (including 1.31 m^2 for the two pipes) were 50 cm/sec for the development site and 10 cm/sec at the reference marsh channels. These agreed closely with field measurements.

67. The majority of the tidal water passed through the two tidal channels (Figure 11) even though a third shallow channel was 250 m north of the large channel (Figure 2 in Volume I). Approximately one-third of the tidal volume passed through the small channel, which had a cross-section of 25 m^2 at a tidal height of 1.2 m as compared to a 45-m^2 cross-sectional area at the large channel.

68. There was no rain in August, yet overcast conditions occurred on the last day (Table 44). The greatest tidal range was 0.90 m during the entire sampling period. The weather conditions were somewhat anomalous in January 1977 as compared to other years. Temperatures were unusually cold (Table 45), and in fact the James River was frozen completely across near Ducking Stool Point a few days after the sampling program. A frontal system with snow moved into the area after the first 24 hours, and a rain squall along with increased wind velocities occurred near the end of the 54-hour sampling period. This was noticed as a slight warming on January 10 (see air temperature in Table 45). This last rain squall was termed preprecipitational ebb (PPE) because it resulted in a premature export of water from the marshes before the normal ebb flow. The greatest tidal range during the January 1977 sampling interval was 1.00 m. This unusually high tide was 0.61 m above those predicted in the tidal tables and 0.15 m above the previous high tide. This caused the larger tidal volume during January (238,000 m^3) at the reference marsh as compared to August (206,000 m^3), an increase in tidal volume of about 15 percent. The reason for the larger changes in tidal volume between sampling periods at the development

site was obscured by the fact that the overall tidal heights were different between August 1976 and January 1977 and that the cumulative area of tidal inundation changed between topographic surveys in 1976 and 1977 (Table 46). Substantial erosion had occurred at the lower tidal elevations during the 2-year period after construction of the development site. As an example, tidal water for a tidal height of 0.76 m occupied negligible surface area in the marsh in 1975, while the same tidal height inundated 1.2 ha of marsh in 1976 and 2.6 ha in 1977. Yet, the total area of inundation remained the same, or about 4.1 ha, during the entire period for tidal heights exceeding 1.37 m.

Methods and Materials

Field techniques

69. Field studies during the initial 1.5 years of the program consisted of collections every 6 hr at the effluent pipe during several 48-hour sampling periods (Volume I). The program during August 1976 and January 1977 was more intensive and consisted of hourly collections at both the development site pipe (AP) and breach (AB) during four complete tidal cycles. Station AP was located on the marsh side of the development site pipe, while samples at AB were collected from the center of the breach. In many instances, duplicate (alpha and beta) were collected simultaneously at each of the four locations in order to determine variability. At the same time, a similar study was conducted at the large (RL) and small (RS) channels of the reference marsh. A 5.8-m research vessel was anchored in the center of the large channel (RL) at the reference marsh, where a small boat was dispatched hourly to collect water samples at the small channel (RS).

70. The sample collection times, along with field current velocity measurements and WES tide gauge tidal height, during the August period are provided in Figures 12, 13, and 14, while similar information for the January period is shown in Figures 15, 16, and 17. Because current velocity measurements and water sampling were not always at the same times, each station, with the exception of RS where no velocity measure-

ments were made, is depicted separately. Water samples were processed for conductivity, temperature, pH, alkalinity, turbidity, total suspended solids, dissolved oxygen, dissolved and particulate nutrients (nitrogen and phosphorus), dissolved and particulate organic carbon, and dissolved and particulate metals (Ca, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, and Zn). In addition, chlorophyll and phaeophytin measurements, as well as the Fo/Fa ratio (fluorescence before (Fo) and after (Fa) acidification with HCl), were made. Current velocities were measured hourly at the development site pipe and breach using either an orange or water-filled balloon, while at the large channel of the reference marsh, a model 160 Endeco (Environmental Devices Corporation, Marion, Massachusetts) remote reading current meter was used for measurements collected at 15-minute intervals.

71. Many of the water and suspended sediment samples were composited before analysis to represent different stages of the tide.* Samples were occasionally collected for the determination of sediment cation exchange capacity (CEC), while more than half of the hourly total nutrient water samples were used to determine silt/clay ratios during different tidal periods. Measurements in the field were conducted for the following parameters: water and air temperature, dissolved oxygen, pH, alkalinity, and turbidity. Filtration for particulate nutrients, carbon, metals, and suspended solids, as well as for chlorophyll and phaeophytin determinations, were conducted at the field laboratory soon after collection. Filtered water samples for dissolved chemical components were stored at 1-2^{o} C, while filters were frozen at -78^{o} C. Ultrex acids were used for storage of water samples for dissolved metals. Dissolved oxygen was measured according to the micro-Winkler method described in Carpenter (1965). Standardized HCl was added to unfiltered water samples for alkalinity, whereupon the sample was bubbled for 15 minutes with nitrogen gas and back-titrated to pH 7.0 with standardized NaOH. Water turbidity was measured with a model 2100A Hach laboratory turbidimeter (Hach Chemical Company, Ames, Iowa).

72. Water samples for particulate and dissolved organic carbon were processed differently than samples for metals and nutrients, which were collected in acid-soaked polyethylene containers and filtered in

* This was done to reduce the number of analyses and yet obtain values representative of each tidal phase.

acid-rinsed plastic systems through membrane filters. The carbon samples were stored in preheated glass containers and filtered through tared pre-combusted glass fiber filters supported in stainless steel Sweeney filter holders fitted to 100-ml glass syringes. These water samples were frozen immediately at -78° C in pre-combusted scintillation vials with pre-combusted aluminum foil inserts. Filters used for particulate organic carbon analysis were stored between pre-combusted aluminum foil. Water samples were also passed through glass fiber filters for suspended solids and plant pigments (chlorophyll and phaeophytin); the latter were stored immediately at -78° C.

Laboratory methodology

73. The following parameters were either processed and measured in the field on an hourly basis or measured in the laboratory without compositing: water and air temperature, conductivity, pH, alkalinity, dissolved oxygen, turbidity, suspended solids, dissolved total organic carbon, dissolved volatile organic carbon, chlorophyll, phaeophytin, the Fo/Fa ratio, and dissolved calcium, iron, manganese, and zinc. These were termed serial data. Also, separate samples from stations AB and RS in August 1976 were not composited but analyzed individually for dissolved $NO_3 + NO_2$ and orthophosphate for comparisons with the composite data.

74. Water conductivity was measured with a model 8400 Autosal laboratory salinometer (Guildline Instrument, Larchmont, New York). Dissolved, volatile, and particulate organic carbon were determined with a model DC-52 Dohrmann carbon analyzer (Envirotech Corporation, Santa Clara, California). For plant pigments, the glass fiber filters were homogenized in 90 percent acetone with a Tekmar model SDT Super Dispax Tissumizer (Tekmar Company, Cincinnati, Ohio) and allowed to stand in the dark for 10 to 20 minutes. Fluorescence was measured on an Aminco fluoro-colorimeter (Aminco Bowman, Inc., Silver Springs, Maryland). Organic carbon samples (particulates on glass fiber filters and sediment TOC) were also homogenized with the Tekmar unit for measurement with the carbon analyzer.

75. Compositing of refrigerated water samples was completed within a few days after collection. Because of the restricted nature of the channels at the development site, tidal stages usually lagged behind the

normal rise and fall of water at the tide gauge and reference marsh. This was especially evident during ebb tide. Therefore, samples were composited according to field current velocity rather than tide gauge information (Tables 47 and 48). Slack water occurred at the same time as negligible current velocities at the reference marsh (Figures 14 and 17). Compositing according to tidal stage was performed for the following parameters: dissolved nutrients (inorganic orthophosphate, total dissolved phosphorus, ammonium, nitrate plus nitrite, and total dissolved nitrogen), total nitrogen and total phosphorus (from unfiltered samples), and dissolved mercury. For the August 1976 period, dissolved ammonium was measured by four different schemes to evaluate storage time and conditions: (a) immediately after compositing samples were stored at 4^{o} C with H_2SO_4 for seven days, (b) duplicate (alpha and beta) composite were stored frozen (-20^{o} C) for 42 days with perchloric acid, (c) single composites were stored frozen for 260 days (8.6 months) with H_2SO_4, and (d) duplicate (alpha and beta) serial samples were stored frozen for 225 to 240 days (7.5 to 8 months) with HCl. After thawing, this last set of samples were composited before analysis.

76. Particulate suspended material was collected by vacuum filtration through tared 0.4 to 0.6-μm Nucleopore membrane filters for metal analysis (Nucleopore Corporation, Pleasanton, California). These were leached with nitric acid and rinsed before the August 1976 sampling period. Later studies indicated that this precation was unnecessary and was therefore discontinued for the January 1977 period. Because of the low recovery of suspended material (approximately 1 mg per filter), all of the duplicates from similar tidal periods, i.e., low slack, flood, high slack, ebb, were combined into single tidal stages at each marsh. Enough material was collected during the flood tide at AP and RL in January 1977 to allow for the separate analysis of duplicate sets of composited filters.

77. Silt/clay ratios were determined for suspended sediments at both marshes in order to have an estimate of the colloidal clay fraction in transport. After thorough mixing, both the alpha and beta duplicate samples from the total nutrient water samples were used to obtain a 350-ml sample. Only those from hour 24 to 48 at station AP and from hour 16

to 48 at station RS were used. This provided at least one complete tidal cycle for both marshes. This sample was centrifuged at 750 rpm for 5 minutes in order to settle the >2 μm particles below a 19-cm depth in the bottles (Jackson 1973). From this depth, 200 ml of samples was pipetted into another centrifuge bottle. Enough saturated NaCl solution was added to both bottles to ensure flocculation. Bottles were than centrifuged at 2500 to 3000 rpm for at least 10 minutes. The supernatent was decanted and the sediment washed three times with methanol and deionized water to remove NaCl. The sediment was then dried at 60° C and weighed. The weight percent >2 μm, WP_2, was found by the following equation: $WP_2 = 100 (a)(v)/200 (a + b)$, where a is the dry weight of the >2 μm fraction pipetted from the sample, v is the original volume, usually 350 ml, and b is the dry weight of the remaining sediment containing all the >2 μm fraction. Thus, (a + b) is the total sample weight. Next, both of the size fractions were recombined and treated three times with 30 percent H_2O_2 in order to remove organic matter, then fully dispersed in deionized water instead of water collected from the James River. An increase in the silt/clay ratio with this latter step may have been due to incomplete disaggregation of the previously dried sediment.

Data evaluation techniques

78. A complete listing of measurements and other numerical observations are provided in Appendix B' for the two field programs at both marshes. Detailed statistics for each parameter are included in Tables C'61 to C'111 in Appendix C'. Data were divided into tidal stages according to the compositing scheme shown in Tables 47 and 48. Serial data were treated in the same manner. The pore water drainage period (PWD) at the development site pipe (AP) and the January 1977 preprecipitational ebb (PPE) samples collected at the development site breach (AB) and reference marsh channels (both RL and RS) were treated separately from the other tidal stages. Computer-generated data plots for each of the variables are provided in Appendix A'.

79. Topographic surveys were conducted three times at the development site in July 1975, April 1976, and March-April 1977 by NOA. One survey during August 1977 was completed at the reference marsh. From these surveys, 0.03-m contour maps of each marsh were constructed, and

surface area inundation for every 0.03 m of tidal height were made available by WES. Area inundation was first converted to tidal water volume. From the concentrations of each variable (serial or composite data), averaged field measurements of the current velocities, changes in water volume with tidal height, and cross-sectional changes at the development breach (Figure 9), tidal mass fluxes for each measured component during flood and ebb were calculated for the breach (AB). Mass fluxes for these parameters were then computed for paired floods and ebbs (usually four of each). Because the measurement of current velocity at the development site pipe was less accurate than of the breach, the calculation of mass flux, as detailed in Appendix D', was adjusted to allow the remainder of the tidal volume, i.e., that which did not flow through the breach, to enter or leave through the development site pipes (Table 49). Current velocity measurements at the large channel of the reference marsh (RL) were not used* because they indicated that only a third of the reference marsh tidal volume would have flowed through RL, which was very unlikely from a comparison of the cross sections for the two channels in Figure 11. Instead, the flux of tidal water entering or leaving through the two channels of the reference marsh was calculated according to changes in the ratios of their respective cross-sectional areas with tidal height (Table 50). As at the development site, mass fluxes were calculated for each ebb and flood and net mass fluxes were computed for the four complete tides.

80. An analysis of variance (ANOVA) was performed using a 2^6 factorial design (marsh, station, day/night, tide, replicate, block) for ebb and flood tidal groups only. Block refers to the first and second 24-hour periods. An F-test was used to determine if each term of the ANOVA was statistically significant. Only those terms significant at the five percent level or lower were considered. Measures of uncontrolled error were also determined by four different methods: (a) variations in the hourly serial data within a tidal group, (b) variations between replicates (alpha and beta), (c) variations between

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* This discrepancy was due to the current meter which could not accurately measure the low velocities encountered.

time blocks 1 and 2, and (d) variations associated with the third and higher order interactions in the ANOVA. Further details and tables are provided in Appendix E'.

Results

Chemistry

81. During these two field programs, a total of 26 different parameters was investigated as to their tidal and seasonal variability as well as compositional differences between the sampling locations. Computer plots are shown in Appendix A', a data printout for each individual parameter is provided in Appendix B', while statistics related to tidal phases are in Appendix C'.

82. Ten parameters were higher at the tidal channels of both marshes during the summer as compared to the winter period. These were water temperature, turbidity, total Kjeldahl nitrogen, Fo/Fa ratio, chlorophyll, phaeophytin, dissolved calcium, dissolved manganese, dissolved mercury, and dissolved zinc (Table 51). Those parameters that were higher in the summer only at the development site were suspended solids, dissolved orthophosphate, dissolved total nitrogen, and dissolved iron. Conductivity was the only parameter that was exclusively higher in the summer than in the winter at the reference marsh. Yet, a seasonal difference was not well established for conductivity at the development site. There were only five measured parameters (pH, dissolved oxygen, oxygen saturation, dissolved NO_3+NO_2, and dissolved total phosphorus) that were higher at both marshes in the winter as compared to the summer. Of these, the largest differences were in dissolved oxygen and dissolved nitrate plus nitrite, with the latter having concentrations 2 to 3 times greater in the winter than during the summer. Dissolved total phosphorus and pH were also higher in the winter. The few parameters that indicated negligible seasonal changes at both marshes were dissolved ammonium, dissolved volatile organic carbon, and total dissolved organic carbon. Conductivity and total phosphorus did not seem to change between seasons at the development site while this was the case for suspended solids,

oxygen saturation, dissolved orthophosphate, and dissolved iron at the reference marsh (Table 51).

83. There were seven parameters, possibly 11, that were higher during both seasons at the channels of the development site as compared to the reference marsh. These were suspended solids, turbidity*, total phosphorus*, dissolved nitrate plus nitrite*, volatile dissolved organic carbon* (most noticeable at the development site pipe), dissolved calcium*, dissolved manganese*, and possibly conductivity*, dissolved total phosphorus, dissolved orthophosphate*, and dissolved zinc (Table 52). Dissolved oxygen* and pH* were the only two parameters that were higher during both seasons at the reference marsh as compared to the development site (see Table 53 for ebb and flood tide levels of significance). Dissolved total nitrogen, dissolved iron, and possibly TKN and dissolved total organic carbon were higher at the development site as compared to the reference marsh in the summer only, while in the winter this was the case for conductivity, alkalinity*, and phaeophytin* and possible water temperature and chlorophyll. Even though a significant difference existed for alkalinity between the two marshes in the winter (Table 53), the poor quality of the August data excluded ANOVA interpretation. Besides pH, dissolved oxygen, and oxygen saturation, which were higher at the reference marsh than the development site for both seasons, the Fo/Fa ratio was the one parameter that was higher only during the winter period. This was significant for the ebb and flood periods. Chlorophyll and phaeophytin were slightly higher (significant at least for the ebb and flood tides; Table 53) at the reference marsh for the summer only (Table 52).

84. A few of the measured parameters indicated some differences between the sampling stations at the tidal channels for each marsh. Suspended solids, turbidity, phaeophytin, dissolved total organic carbon, TKN, dissolved manganese, and possibly dissolved iron and dissolved orthophosphate were always higher at the development site pipe (AP) as

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* These parameters were significant during both seasons for at least the ebb and flood tidal periods, as shown in Table 53.

compared to the breach (AB), while this was possibly the case for TKN and total dissolved nitrogen at the large channel (RL) as compared to the small channel (RS) of the reference marsh for both seasons (Table 54). Only the Fo/Fa ratio might have been slightly higher at the breach during both seasons as compared to the pipes. Nine additional parameters, which were higher at the pipe as compared to the breach during the summer only, were conductivity, dissolved total phosphorus*, total phosphorus (unfiltered), dissolved volatile organic carbon, dissolved calcium*, and possibly dissolved mercury. At the breach, pH, dissolved oxygen (and oxygen saturation), dissolved nitrate plus nitrite, dissolved total nitrogen, chlorophyll, and possibly dissolved ammonium and dissolved zinc* were higher as compared to the pipe in the summer. Dissolved nitrate plus nitrite*, dissolved total nitrogen*, particulate carbon, and possibly chlorophyll and dissolved zinc* were higher at the pipe as compared to the breach during the winter sampling period, while conductivity, dissolved total phosphorus*, and total phosphorus* (unfiltered) were higher at the breach in winter. Data for particulate carbon were only available for the winter period, therefore, it was not known whether the summer would provide similar results. Dissolved total phosphorus*, total phosphorus (unfiltered), and dissolved nitrate plus nitrite were higher at RS as compared to RL at the reference marsh in the summer, while dissolved oxygen, chlorophyll, phaeophytin, and dissolved calcium* were lower (Tables 54 and 55). During the winter period, dissolved volatile and total organic carbon, particulate carbon, and dissolved iron were possibly higher at the small channel (RS) as compared to RL, while dissolved zinc*, and possibly dissolved total phosphorus*, dissolved ammonium, dissolved nitrate plus nitrite*, dissolved total nitrogen*, and TKN* were higher at RL as compared to RS.

85. The drainage of constituents from the development site pipes was also compared for the sum of three ebb tidal phases (PWD or porewater

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* These were significant at least for ebb and flood (Table 55).

drainage, ebb, and low slack) and the other periods of the tide (flood and high slack). Concentrations at the pipe were greater than at the breach because of the drainage of interstitial water from the interior sediments of the habitat. PWD and low slack tidal phases occurred only at the pipe because the breach was dry during this time period. As evidenced by eight different measured parameters (see those marked with an asterisk in Table 56), concentrations were higher for ebb tidal phases during both seasons of the year, while an additional six (suspended solids, turbidity, dissolved orthophosphate, dissolved total phosphorus, dissolved total organic carbon, and dissolved calcium) were higher only in the summer and TKN was the only parameter that was exclusively higher in the winter. Thus, 60 percent of the measured parameters at the habitat pipe during ebb were higher either for one or both seasons. None of the parameters were higher in the flood waters during both seasons; yet, during the summer, pH, dissolved oxygen (and oxygen saturation), dissolved nitrate plus nitrite, TKN, chlorophyll, and dissolved mercury were lower at the pipes during the ebb as compared to the flood (Table 56). Notably, the Fo/Fa ratio and dissolved zinc were the only parameters that did not show a tidal preference at the development site pipe during the summer, while the number increased to at least 16, and possibly 20, parameters in the winter (Table 56).

86. There were significant differences between the two marshes when the measured parameters were examined by ANOVA for the ebb and flood tidal periods only. At least 13 of the parameters were significant for both seasons (Table 53). Eight of these 13 parameters had higher concentrations at the development site: conductivity, total phosphorus, turbidity, and the dissolved components of phosphate, nitrate and nitrite, calcium, manganese, and volatile organic carbon. Dissolved iron, suspended solids, and total dissolved nitrogen were significantly higher at the development site in the summer. During the winter, water temperature, total dissolved phosphorus, phaeophytin, and dissolved zinc were higher at the development site. Dissolved oxygen (and oxygen saturation) and pH were the only parameters that were significantly higher at the refer-

ence marsh during both seasons. Chlorophyll and phaeophytin were significantly higher at the reference marsh during the summer, while the Fo/Fa ratio and dissolved iron were the only two parameters higher at the reference marsh for the winter sampling period.

87. The concentrations of some parameters changed with the ebb and flood tidal phases (Table 55). During both the summer and winter periods, dissolved oxygen (and oxygen saturation) were significantly higher at both marshes during the flood, while dissolved manganese was higher during the ebb tide. Only during the summer at both marshes was dissolved orthophosphate, iron, and volatile organic carbon significantly higher at ebb tide, while pH and chlorophyll were higher during the flood tide. There were fewer tidal effects in the winter with the exception of dissolved oxygen, water temperature, and phaeophytin, which were greater during the flood tide. There were some parameters that exhibited significant differences during the ebb and flood tidal periods because of the sampling location. The most important parameters at both marshes during both seasons were dissolved total phosphorus, dissolved calcium, and dissolved zinc (Table 55). Seven additional parameters showed significant differences between the four stations at the two marshes in the winter.

88. The diurnal changes that occurred at the marshes were obviously water temperature, but more important were the significant day to night changes for ebb and flood samples during the summer for some biologically influenced constituents such as pH, dissolved oxygen, the Fo/Fa ratio, and phaeophytin. There was a significant variability in the concentrations of replicates (alpha and beta) during the ebb and flood tidal cycles for dissolved total phosphorus in the summer and dissolved orthophosphate, calcium, and zinc in the winter (Table 55).

89. The average clay/silt ratio for untreated suspended sediments at the reference marsh tidal channels during both seasons (2.5) was significantly greater than the ratio at the development site channels (1.0) (Figures 18 to 23). After the suspended sediments were treated with 30 percent H_2O_2, the average clay/silt ratio at the reference marsh tidal channels (1.4) was more nearly the same as that determined for the development site (0.9). This ratio at the reference marsh

channels was slightly higher than the clay/silt ratio of the H_2O_2 treated and dispersed sediments collected from the marsh substrate. However, the suspended sediments at the development site breach and pipes had the same ratio as sediments collected from cores within the development site (Table 31). Although the mean clay/silt ratio of untreated suspended sediments increased from summer to winter at the reference marsh, the mean ratio of only the H_2O_2 treated clay/silt fraction at the development site increased during this time period (Figures 19, 21, and 22). There were no consistent relationships between the clay/silt ratio and tidal phases or current velocities. Yet, more of the ebb tide samples were above the mean clay/silt ratio than were seen during the flood tide.

90. Like the clay/silt ratio at the reference marsh tidal channels, the CEC of the suspended sediments was significantly higher (151 meq/100 g) than that of the sediment substrate from within the marsh (66 meq/100 g; Tables 34 and 57). Similarly, the CEC of suspended sediments at the development marsh (99 meq/100 g in January) was significantly greater than the surface sediments within the confining dikes (32 meq/100 g; Table 34). While the ebb tide suspended sediment CEC was consistently greater than flood at the reference marsh for both seasons, the opposite was true at the development site, but only in the winter.

91. As explained in Appendix D', the mass import and export of each parameter was calculated for both channels at the two marshes during the summer and winter periods. These were computed for each of the four floods and ebbs, and net mass transport was derived for the entire 48- or 54-hour periods. Errors associated with the concentration measurements and the velocity portion of the volume calculations were at times larger than the net mass transport. These are noted in the tables, where the transport terms have also been normalized so that equal tidal volumes entered and left the two marshes. Only net mass export and import of variables that were significantly greater than the error terms are listed in Tables 58 and 59. There was significant export of dissolved volatile organic carbon, dissolved orthophosphate, and particulate copper at the breach and pipe of the development site during the summer,

while in the winter this was the case for dissolved total and volatile organic carbon, alkalinity, and possibly particulate cadmium (Table 58). There was also export of dissolved total nitrogen at the pipes and dissolved manganese and dissolved total phosphorus at the breach in the summer, yet in the winter dissolved mercury was the only parameter that indicated an export at the pipes. The situation was different at the reference marsh with seven parameters showing significant export at both channels in the summer and none in the winter (Table 58). Moreover, in the summer, there was significant export of dissolved volatile organic carbon, dissolved iron, and particulate lead at the small channel, while dissolved nitrate plus nitrite, dissolved total phosphorus, and particulate cadmium were exported at the large channel. In the winter, both dissolved total organic carbon and particulate cadmium were lost through the small channel.

92. Fewer of the measured parameters were imported to the marshes than were exported. Ten variables showed significant export at the development site during the summer and winter, while seven were imported. At the reference marsh, 14 variables were exported in summer and 11 in winter. During the summer there was significant import of dissolved oxygen at both channels of the development site, yet in the winter this seemed to be the case only for particulate manganese (Table 59). Only dissolved volatile organic carbon and particulate manganese showed significant import at both channels of the reference marsh during the winter. During the summer at the development site, net mass import occurred at the breach for particulate manganese and at the pipes for total phosphorus and dissolved zinc (Table 59). The same was true for suspended solids in the winter at the pipes and dissolved total nitrogen and orthophosphate at the breach. Dissolved total nitrogen was imported at the small channel of the reference marsh during the summer, while dissolved ammonium and particulate zinc indicated significant import at the large channel. There were six parameters that showed significant import at one of the channels of the reference marsh during the winter. Five of these were imported through the large tidal channel (Table 59) while at the small channel only one (alkalinity) was imported.

93. Numerous measured parameters exhibited net mass export at one channel and import at the other. This was the case for 14 variables at the development site in both summer and winter as compared to seven variables in the summer at the reference marsh and 12 in the winter (Table 60). In the summer, over twice the number of variables were exported through the pipes as compared to the breach, yet in the winter this was divided relatively evenly between the pipes (six variables) and breach (eight variables). However, at least double the number of variables were exported through the small channel at the reference marsh as compared to the large channel, regardless of season. Half of the net mass export valves at RS were significant during the two seasons (Table 60).

Discussion

94. Tidal studies conducted after vegetation was established at the development site, indicated negligible tidal mobilization of dissolved pollutants. Of the dissolved metals studied, only calcium, manganese, mercury, iron, and zinc, were within the detection limits (Table 5 in Volume I) and could be included in mass transport calculations. A small export (2.5 g) of dissolved mercury was calculated for the development site during the winter sampling program. Particulate copper, lead, and nickel were exported from the site during the August sampling period while cadium was the only exported metal detectable during the January sampling period. Export of these four metals from the reference marsh during the same sampling periods were greater, however, and ranged from 3 to 150 times higher. There was only 3 to 8 times less export of particulate copper and cadmium at the development site compared to the reference marsh but the mass export of copper was relatively high (124 g). Yet, the major portion of copper was probably associated with the sediment residual phases (Table 38) and would probably not be available for biological utilization. The phases for cadmium were not known. Because of the low recovery of suspended solids, particulate mercury was not measured. As pointed out later, the ratio of 3 to 8 for particulate Cu and Cd mass transport was also similar to intertidal surface substrate relationships

(Table 46). As discussed later, major losses from the development site were observed for dissolved total nitrogen and both volatile and total dissolved organic carbon.

95. With exception of the possible resuspension and introduction of particulate and interstitial water components from the large delta outside of the development site pipes, it was assumed that the flood waters entering the two marshes represented the background composition of James River or Herring Creek. From column three in Table 23 (Volume I) and the statistics in Appendix C', the composition of the source waters for these two marshes was relatively similar with exception to levels of conductivity and temperature in January and concentrations of suspended solids, dissolved manganese, and dissolved zinc in August. The mixing of flood waters with marsh sediments and interstitial waters and subsequent losses of various species to the overlying waters, as well as the addition of detrital components of vegetative origin from the marsh surface, would usually result in a net export from the marsh. Since exchange processes between interstitial and overlying tidal waters are considered to be of greater magnitude than sediment-water interactions during the 6-hour flooding period of the tide, it was expected that a large export indicated that such dynamic processes were taking place at the sediment-water interface (Hallberg et al. 1973) within the marshes. The transport of materials across this interface would certainly be increased by the actions of organisms, called bioturbation, and physical processes such as methane degrassing and mixing due to winds, rain, and currents.

96. At first it was thought that the physical location of sample collection sites at the pipe and breach of the development site as compared to the tidal channels at the reference marsh would jeopardize a proper interpretation of the data because of the height above the channel bottom, i.e., the reference marsh channels were approximately 1.5 - 2 m deeper than development sites. Since water samples in the reference marsh channels were collected 5 to 15 cm below the water surface, the concentrations of near surface samples (Cy) relative to near-bottom

concentrations (Ca) were calculated for suspended solids using the following equation:

$$\frac{Cy}{Ca} = \left[\frac{D-y}{D-a} \cdot \frac{a}{y}\right]^{z}$$

where a = 0.05 D or the depth of flow, y is the distance above the bottom at which the sample was collected, and $z = W/\kappa U^*$ (where $W/\kappa U^*$ is the average settling velocity of particles, κ is 0.4, the von Karman constant for a smooth bottom, and U^* is the shear velocity). The lowest ratio of Cy/Ca would occur at slack water where U^* approaches zero. If it is assumed that particles were all about 0.1-mm diameter, a value of 0.77 would be calculated for the Cy/Ca ratio. For dispersed particles of 5-μm diameter at slack water, this ratio would be 0.98 at a depth of 1 cm below the water surface. Thus, at least 77 percent of the maximum suspended solids concentration, with an average of about 90 percent, was collected near the surface of the two reference marsh channels.

97. There were obvious differences between the two marshes with respect to the concentrations of various parameters at the tidal channel. Those that exhibited significant differences during the ebb and flood tides are listed in Table 53, while mean concentrations at the tidal channels of the two marshes are provided in Tables 51 and 52. At least 70 percent of the parameters that exhibited significant differences showed higher concentrations at the development site. With the exception of suspended solids, total dissolved nitrogen, and chlorophyll in the summer, and water temperature, the Fo/Fa ratio, total dissolved phosphorus, and dissolved zinc in the winter, 13 other parameters listed in Table 53 were significantly different between the two marshes during both seasons. Except for particulate metals, these represented half of the measured parameters. It was possible that these differences were due to the natural variability of such freshwater marshes rather than the composition of the recently dredged substrate that constituted one of the sites. It is obvious that future experimental designs should include at least two natural marshes in order to test such interpretations. Because the marsh surface was slightly frozen during the winter sampling

program, very little resuspension of the marsh substrate and a decrease in the transport of dissolved components across the sediment-water interface would have certainly occurred. This was most noticeable as a decrease in suspended solids and turbidity of the water leaving the marshes (Table 51) as well as the number of variables that were exported seasonally, especially at the reference marsh (Table 58).

98. The mobilization and export of different components, whether natural or of a pollutant nature, would be a function of the area of marsh surface inundation during each tide, the difference in concentration between the overlying tidal water and sediment interstitial water, and the rate of transport between the marsh substrate and the overlying waters. The relationship of tidal volume to area of water inundation would be most important since mobilization across marsh substrates would effect the quantity of mass export. For tides above one meter, the ratio of surface areas was about 4 to 1 (reference to development site) and decreased to a minimum of 3.6 to 1 for the highest tides (Table 46). Below one meter, this ratio increased more rapidly in 1976 than it did in 1977, where at about 0.75 meter it varied from 16 to 1 (1976) to 6 to 1 (1977) and at 0.5 meter from 10,200 to 1 (1976) to 390 to 1 (1977). This investigation did not address the relationships between mass transport and tidal inundation of marsh substrates with respect to recently dredged substrates versus natural well-established freshwater marshes. However, a 4 to 1 ratio for tidal inundation between the two marsh surface substrates could be applied as a first approximation to the net mass transport values listed in Tables 58 to 62. The tidal prism volume relationships between the two marshes changed from about 7.8 to 1 (reference to development site) in August 1976 to 5.7 to 1 for January 1977 (Tables 49 and 50) as a result of substantial intertidal erosion at the development site during the period between topographic surveys.

99. The lack of a significant export of suspended solids during both sampling periods at the development site was puzzling. It was possible that resuspension of delta material outside the pipes during the flood distorted the calculation of net mass transport and also provided an apparent import of suspended sediments. Regardless, there was a sig-

nificant export of particulate copper and possibly iron at the development site in the summer and particulate cadmium in the winter (Table 58). The export of particulate cadmium was very small, however, and averaged only 0.9 $\pm$ 0.3 g over the four tidal cycles. Other particulate metals exported at the development site were calcium and lead in the summer. Three of the particulate metals were imported in the summer (manganese, zinc, and cadmium) as compared to the winter import (manganese, iron, calcium, zinc, copper, and lead; Table 61). The export of particulate copper (summer) and cadmium (winter) occurred in about the same ratio as the area of inundation between the two marshes. Particulate copper export might have been slightly higher at the development site. In addition, there was an export of particulate nickel, lead, and cadmium at both channels of the reference marsh (Table 58) and particulate iron and calcium at one channel in the summer. Particulate zinc was the only metal imported in the summer at the reference marsh, with the exception of manganese, which will be discussed later. Particulate manganese, iron, calcium, lead, and copper were imported through both channels at the reference marsh in the winter, while particulate nickel showed a larger winter export than net mass import.

100. With exception of Ca, Fe, Mn, Zn, and Hg, the dissolved concentrations of the other metals were below detection limits (Table 5 in Volume I). Particulate Hg was not measured in the suspended sediments. The greatest transport of iron was in the particulate phase, where values exceeded dissolved net mass transport by 3 to 60 times (Table 61). Calcium and zinc, however, existed in the dissolved phase, where solution exceeded particulate transport by 3 to 94 for calcium and 1.6 to 34 for zinc. The greatest differences between dissolved and particulate transport occurred at the reference marsh. This probably reflected the larger volume to surface area of the reference marsh. There were seasonal changes in the net mass transport of manganese, where dissolved export exceeded particulate import by 1.3 to 6.5 times in the summer at both marshes, and particulate import exceeded dissolved export by 2.5 to 15.5 times in the winter (Table 61). Six of the nine metals were exported

from the development site in the summer, while all nine exhibited a greater export at the reference marsh. However, the situation was reversed during the winter sampling period where seven of the nine metals were imported into both the development site and reference marsh. If both dissolved and particulate phases were combined and the two sampling intervals were considered to represent the entire annual periods of growth and dormancy of the marshes, a balance between export and import existed for Ca, Fe, Pb, Mn, Hg, and Ni at the development site and only Mn at the reference marsh. During August and January there was a greater import of both phases of zinc into the development site, possibly in response to biological utilization during the initial very productive 2 years. Over both seasons, copper was exported in the particulate phase to a larger extent than it was imported. This was also the case at the reference marsh, where during both seasons there was a larger overall export of Cd, Pb, Hg, Ni, and Zn as well as Cu (only the particulate phases were used for the transport calculation because dissolved phases with exception of Zn, were below detection). Suspended sediments at the reference marsh tidal channels also exhibited higher CEC measurements than at the development site, which suggested that at least a portion of the transport was associated with this fraction. In contrast, only Ca and Fe were shown to exhibit a greater overall import during both seasons at the reference marsh if both dissolved and particulate phases were considered.

101. As shown in Part II, there was a substantial difference between the two marshes in total manganese concentration in the sediments (Table 30) with values at the reference marsh measuring only one-third of those at the development site. It was suspected that Mn was mobilized from sediment phases into the interstital water dissolved phase and was eventually lost to the overlying tidal waters. Since both marshes were intertidal, the difference in total Mn was attributed to the longer period of tidal flooding and flushing at the reference marsh (200+ years) as compared to the development site (2 years). Data presented in Tables 58 to 61 certainly substantiated this interpretation: dissolved Mn was lost from both marshes during August and January. Because of its relatively slow oxidation rate (Stumm and Morgan 1970),

exported dissolved Mn (II) was eventually transformed into various insoluble phases and measured as imported particulate Mn (Table 61). Because of increased bioturbation and bacterial processes in the summer, export was higher from both marshes than in the winter. This is also seen (Table 56) as seasonal differences in flood and ebb tidal cycles at the pipes. The net mass export ratio of 3.5 to 1 (reference to develement site) of dissolved Mn during the ebb tide compared favorably to the substrate ratio of 4 to 1 (reference to development site) for tidal inundation. The loss of dissolved Mn(II) to the tidal waters was also observed as a seasonal phenomenon that was closely related to the larger source of dissolved manganese during the summer. Concentrations in the particulate phase averaged 2,000 μg/g in the summer, while during the winter period of low biological activity (and thus less dissolved Mn transport across the sediment-water interface) particulate phase Mn averaged 600 μg/g (Appendix B'). This was also the case for dissolved iron during the summer at both marshes, except that it was exported from the marsh in both dissolved and particulate phases. The tidal inundation substrate ratio of 4 to 1 between the reference and development marshes did not apply, as was the case with Mn, to the export of Fe in the dissolved phase (34 to 1). This suggested that either iron export was restricted at the development site due to precipitation as ferric phosphates, hydroxides, and oxides or that the chemical cycle of dissolved iron cannot be closely related to manganese, at least with respect to these two marshes. The concentration of interstitial phosphate in the development site sediments was, however, double the values measured at the reference marsh in the summer (Table 28), and therefore greater $FePO_4$ precipitation in the upper oxidized zone of the sediments could occur. As shown later, these compounds might be present as colloidal material which cannot be partitioned by membrane filtration. Perhaps maturation and complexation of iron with natural organic chelators or as polymerized ferric hydroxo complexes (Hallberg et al. 1973) were important for its mobilization. Even though the percentages of Fe and Mn were similar in the sediment organic phase (Table 38), the overall abundance of iron was much greater and would therefore allow for a

different magnitude of transport across the sediment water interface. Therefore, transport in the dissolved phase could have been higher at the reference marsh and provide a ratio of 34 to 1 (reference to development site; Table 61) since dissolved Fe(III, II)-organic chelates and complexes or Fe(III) hydroxo sols exhibit a greater resistance to oxidation and eventual precipitation than would dissolved ferrous iron species. As with Mn, the average concentration of Fe in the particulate phase was higher in the summer (about 50,000 μg/g) than in the winter (36,000 μg/g; Appendix B').

102. Concentrations of organic and inorganic electrolytes in solution, measured by conductivity, are closely related to the bacterial processes of organic decomposition. Kuznetsov (1970) reported maximum values in the summer for the bottom waters of Russian lakes as a result of the release of microbial decay products from bottom silts. Conductivity measurements were always higher in the tidal channels at the development site as compared to the reference marsh. This situation persisted into the winter period at the development site, and yet this was not the case at the reference marsh tidal channels (Tables 51 and 52). This indicated that bacterial decomposition was still occurring during the winter sampling period at the development site or that the sediments continued to leach decay products that had built up from the previous fall. As shown previously, this was also evident as a continual, albeit lower, loss of dissolved manganese from the two marshes in the winter; yet, if the two marshes were compared there was a substantially greater loss from the development site as compared to the reference site (Table 61; change from 3.5 to 1 mass export ratio in the summer to unity in the winter). Dissolved volatile organic carbon compounds, which are liberated during the initial stages of anaerobic decomposition (Foree and McCarty 1970, Otsuki and Hanya 1972, and Adams 1973), exhibited a net export during both seasons at the development site, yet were lower in the winter. It should be noted, perhaps fortuitously, that the net import of dissolved oxygen at the development site balanced the export of dissolved volatile organic carbon. The liberation of these compounds from the recently dredged substrate probably represented

a substantial portion of the oxygen demand since these compounds would be excellent substrates for bacterial utilization. This is obviously an area for future studies. During both seasons, dissolved total organic carbon* was exported from both marshes during August and January. The volatile portion of the dissolved organic carbon compounds was about 25 percent for the development site tidal waters and 15 percent at the reference marsh. This represented a substantial loss of DOC from both marshes that was not reflected in changes to the bulk carbon content of the marsh sediments (Table 28). The unusually large export of DOC during the winter probably reflected three high concentrations during the pre-precipitational ebb period at the small channel of the reference marsh (Figure A'74). In fact, volume normalized net mass export was 368 kg at RS compared to 146 kg at RL, which was abnormal. If the DOC mass associated with the last ebb and flood cycles were removed from the transport calculations at RS in January, the net export through the small channel was about 13 kg and would provide a winter DOC loss of 159 kg from the reference marsh rather than 514 kg. A rain storm that occurred before the last ebb tide probably flushed the marsh's surface of accumulated dissolved organic products. The spring and early summer periods were not sampled, therefore an annual budget would be difficult to ascertain. Axelrad et al. (1976) reported annual net losses of both dissolved and particulate carbon from two saltwater marshes on the York River, Virginia. They observed a loss of 6.5 times as much POC during a July thunderstorm as was recorded during the next highest period of export. However, this was not the case with POC for the two James River marshes, probably because of the lack of vegetation in January.

103. As shown in Volume I, the relationships of dissolved ammonium to total dissolved nitrogen provided information concerning organic decomposition within the interstitial water of the James River channel

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* It should be remembered that the measurement of dissolved total organic carbon includes dissolved volatile organic carbon as a portion of the total, and that these were treated as such for the calculation of mass transport. The same would also apply to TKN, TDN, TP, and TDP for water samples collected during the August and January tidal studies.

sediments as well as an indication of tidal mixing with nutrient-enriched sediment pore water during the early stages following containment of the dredged sediments. Dissolved phosphate was about 47 percent of TDP (PO_4/TPD = 0.47) in the upper section of the channel cores and increased to an average of 0.61 with depth, probably as a result of bacterial decomposition of dissolved organic phosphorus compounds to dissolved inorganic orthophosphate as an end-product. However, dissolved ammonium was about 90 percent of TDN (NH_4/TDN = 0.90) in the surface half meter of sediments and was relatively constant with depth, indicating that decomposition of nitrogen compounds to inorganic NH_4 was relatively rapid. In May 1975 (3.5 months post-dredging), the PO_4/TDP and NH_4/TDN ratios were 0.5 and 0.6, respectively, during low tide sampling at the pipes, while the contribution of dissolved phosphate and ammonium to the total dissolved components decreased substantially during high tide (PO_4/TDP = 0.3 and NH_4/TDN = 0.2). In August 1976, water samples collected during the pore water drainage tidal phase at the pipe had the same composition (PO_4/TDP = 0.76; NH_4/TDN = 0.22) as the development site sediment interstitial water (PO_4/TDP = 0.74; NH_4/TDN = 0.21). During August, the percentage of dissolved phosphate increased during the ebb tide at the development site (PO_4/TDP = 0.86) above that of the pore water, while during the flood it diminished (0.66). Perhaps orthophosphate existed along with ferric iron as colloidal substrates (Stumm and Morgan 1970) in the surface sediments, which could not be separated by membrane filtration. Upon analysis, this fraction would provide a higher PO_4/TDP ratio for the ebb tide than would normally be present in the interstitial waters or by mixing of tidal waters with the former. Dissolved phosphate and TDP were exported from both marshes in the summer (Table 62). Even though the concentration of TDP was higher in the sediment interstitial waters at both marshes, the export of dissolved phosphate was greater perhaps as a result of such interaction of tidal waters with surface Fe(III) hydroxo-phosphate colloidal material. With the exception of pore water drainage at the development site, the NH_4/TDN ratio of the ebb and flood was 0.11 and 0.14, respectively, or about half the August 1976 sediment interstitial water composition (0.21).

104. A greater amount of dissolved orthophosphate, as compared to TDP, was seen in the tidal waters (flood = 0.45, ebb = 0.51) of the reference marsh in the summer than would have been predicted as loss from the sediment interstitial waters (PO_4/TDP = 0.33). This either suggested an outside source or, as with the development site, a greater mobility of dissolved colloidal phosphate compounds from the sediments. Since there was a net export of both PO_4 and TDP during the summer, the latter was most likely the case especially since the two parameters exhibited a ratio of 0.85 for their mass exports (Table 62), which was well above the tidal or interstitial water composition ratios. An outside source for dissolved ammonium was suspected at the reference marsh in the summer because both the NH_4/TDN ratio was 0.27-0.38 as compared to sediment porewater composition of 0.16 and each of the two parameters indicated a net mass import. It was possible that the large export of 292 kg of TKN was partially decomposed outside the marsh in Herring Creek and returned as dissolved total nitrogen and ammonium (Table 62). This situation was quite different in winter than in summer conditions, yet there was a similarity at both marshes. Sediment interstitial water had the same composition at both sites in the winter (PO_4/TDP = 0.50 to 0.55; NH_4/TDN = 0.51 to 0.53), while tidal channels at the development site and reference marsh exhibited lower ratios. Porewater drainage was no different than other tidal stages at the development site (PO_4/TDP = 0.37 to 0.41; NH_4/TDN = 0.15 to 0.19). The total component of dissolved phosphorus and nitrogen compounds at the reference marsh tidal channels averaged 34 percent dissolved phosphate (0.34 ratio) and 17 to 20 percent dissolved ammonium (0.17 to 0.20 ratio) which was similar to the development site. This suggested that there was little exchange between the sediment interstitial waters and overlying tidal waters during the winter. This could be due to both the lack of bioturbation and the frozen marsh surface sediments.

105. From mass transport calculations of the different nitrogen species at the development site, it was most likely that the rapid depletion in bulk TKN from an average of 3,376 µg/g in July 1975 (6 months post-dredging) to 765 µg/g 13 months later (Table 28) was

partially caused by the mobilization and export of total dissolved nitrogen compounds and not dissolved ammonium. The same was observed by Nixon et al. (1976a) for nitrogen loss from bottom sediments in Narragansett Bay, Rhode Island, where at least half of the flux was in the form of dissolved organic nitrogen. Aerobic nitrification of dissolved ammonium also led to some export of nitrate plus nitrite (Tables 58 and 62). The decomposition of TDN in the waters outside of the development site resulted in a slight import of dissolved ammonium. Losses of N_2 and N_2O during dentrification were not measured. There was a greater export than import of nitrogen from the reference marsh, an observation also made by Axelrad et al. (1976) for two marshes on the York River, Virginia. These authors also stated that particulate nitrogen was exported only during the fall and winter seasons. This was the case for TKN measurements at the reference marsh (Table 62), which would imply that such processes might be reversed in the spring and early summer. Contrary to findings by Axelrad et al. (1976) with respect to TDN compounds and (Woodwell et al. 1976) for dissolved ammonium, both of these measured parameters were imported to the reference marsh in the summer. However, there was export from the reference marsh of both parameters in the winter, which is in agreement with results from the York River marshes (Axelrad et al. 1976). As substantiated by further studies at Flax Pond by Woodwell et al. (1977), the reference marsh was a net consumer of phytoplankton during both seasons. This was also the case for the development site during the summer sampling period as seen by the net mass import of chlorophyll (Table 62).

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Table 26

Summary of Collections for the 7-cm Diameter Sediment Cores and Surface Samples During Various Field Studies at the James River Artificial Habitat Development Site and a Reference Marsh

Date	Total Number of Cores	Number of Sites from Which Cores Were Collected: Habitat	Number of Sites from Which Cores Were Collected: Reference	Purpose
July 1975	14	7	—	Probe analysis
	6	3*	—	Probe analysis and chemistry
	11	11	—	Mineralogy, size and physical description
July 1976	19 (surface samples)	19	—	CEC
August 1976	1	—	1	Physical description
	18	3*	3*	Probe analysis, chemistry, CEC and size
January 1977	18	3*	3*	Probe analysis, chemistry and CEC
June 1977	4	2	—	CEC, special studies

* Locations which were divided into high marsh, intertidal, and subtidal

Table 27

Summary Statistics for Field Observations (Temperature, pH, and Eh), Percent Water, and Volatile Solids for Sediments from the Artificial Habitat Development Site and a Reference Marsh, James River, from July 1975 to January 1977. Channel Data are Provided as a Comparison

		James River Channel	Artificial Marsh			Reference Marsh	
Parameter	Statistic	January 1975	July 1975	August 1976	January 1977	August 1976	January 1977
Temperature (°C)	Mean	13.6	21.8	23.1	- 1.2	24.3	0.5
	Std. Dev.	2.9	3.7	1.5	3.9	2.0	1.3
	Number	22	13	18	18	18	18
pH	Mean	6.70	6.78	6.61	6.73	6.19	6.24
	Std. Dev.	0.22	0.40	0.35	0.31	0.49	0.55
	Number	21	13	26	23	24	26
Eh* (mV)	Mean	-25	+72	+ 105	+ 124	+ 128	+ 173
	Std. Dev.	54	110	100	117	53	43
	Number	22	13	25	23	26	26
Water (%)	Mean	50.8	38.7	47.0	44.2	66.1	67.9
	Std. Dev.	6.4	15.5	14.9	11.8	12.8	10.7
	Number	21	12	17	18	18	18
Water (%) (0-5 cm)	Mean	54.8	50.6	56.1	49.3	70.3	75.9
	Std. Dev.	5.4	9.6	7.9	11.1	13.7	6.0
	Number	10	26	9	9	9	9
Volatile Solids (%)	Mean	14.5	--**	7.2	7.8	15.1	16.6
	Std. Dev.	1.9	--	3.4	3.1	6.3	6.3
	Number	20	--	17	18	18	18
Volatile Solids (%) (0-5 cm)	Mean	13.8	4.9	10.9	8.9	17.4	19.2
	Std. Dev.	1.4	1.0	1.5	2.3	7.7	7.7
	Number	10	26	9	9	9	9

* Corrected for the potential of the saturated calomel electrode

** Not measured over entire depth of cores collected in July 1975

Table 28

Summary Statistics for Interstitial and Total Nutrients and Organic Carbon for Sediments from the Artificial Habitat Development Site and a Reference Marsh, James River, from July 1975 to January 1977. Channel Data are Provided as a Comparison

Parameter	Units	Statistic	James River Channel	Artificial Marsh			Reference Marsh	
				July 1975	August 1976	January 1977	August 1976	January 1977
INTERSTITIAL								
TDP	mg/l	Mean	0.456	0.222	0.136	0.139	0.160	0.164
		Std. Dev.	0.153	0.081	0.047	0.024	0.084	0.027
		Number	20	12	18	17	21	22
ortho-PO_4	mg/l	Mean	0.252	0.054	0.100	0.076	0.059	0.082
		Std. Dev.	0.152	0.010	0.020	0.012	0.010	0.013
		Number	20	12	18	19	19	24
TDN	mg/l	Mean	69.66	34.22	12.66	5.56	10.16	3.52
		Std. Dev.	14.92	14.12	8.14	2.41	9.65	1.21
		Number	20	12	18	17	21	22
NH_4	mg/l	Mean	63.49	31.46	2.65	2.96	1.59	1.79
		Std. Dev.	12.50	8.40	1.89	1.25	1.21	0.52
		Number	43	10	18	19	20	24
$NO_3 + NO_2$	mg/l	Mean	0.064	0.024	0.100	0.106	0.119	0.104
		Std. Dev.	0.018**	0.009	0.020	0.049	0.047	0.052
		Number	20	12	18	19	19	24
DOC	mg/l	Mean	*	60.6	36.3	19.9	28.4	16.2
		Std. Dev.		16.0	15.6	7.1	14.1	4.6
		Number		11	26	24	25	25
TOTAL								
TP	μg/g	Mean	662	814	746	690	666	648
		Std. Dev.	110	58	311	328	407	416
		Number	39	16	27	24	25	25
TKN	μg/g	Mean	4,577	3,376	765	531	1,540	1,010
		Std. Dev.	684	707	360	285	823	398
		Number	39	16	27	24	25	25
TOC	μg/g	Mean	*	17,140	10,400	12,170	12,000	12,750
		Std. Dev.		1,590	2,050	1,950	2,460	2,176
		Number		11	27	24	25	25

* Not measured in channel sediments

** Standard deviation calculated for dissolved nitrate only

Table 29

Summary Statistics for Interstitial Metals (mg/l)* for Sediments from the Artificial Habitat Development Site and a Reference Marsh, James River, from July 1975 to January 1976. Channel Data are Provided as a Comparison

Parameter	Statistic	James River Channel	Artificial Marsh July 1975	Artificial Marsh August 1976	Artificial Marsh January 1977	Reference Marsh August 1976	Reference Marsh January 1977
Ca	Mean	215.9	60.6	81.5	65.2	26.5	13.4
	Std. Dev.	59.3	25.8	28.7	33.0	18.6	9.0
	Number	44	30	20	18	21	25
Fe	Mean	57.3	23.9	30.7	20.8	33.7	12.3
	Std. Dev.	26.7	12.6	16.6	14.4	26.1	10.9
	Number	44	30	20	18	21	25
Mn	Mean	6.94	2.68	3.82	2.84	1.44	1.27
	Std. Dev.	3.88	1.22	1.37	1.22	1.12	1.28
	Number	44	29	20	18	21	25
Zn	Mean	0.120**	0.322	0.063	0.056	0.075	0.053
	Std. Dev.	0.190	0.286	0.069	0.040	0.045	0.028
	Number	31	29	20	18	21	25
Cu	Mean	0.012	†	0.029	††	0.045	††
	Std. Dev.	0.014		0.029		0.049	
	Number	36		17		5	
Cr	Mean	‡	††	0.034	††	0.035	††
	Std. Dev.			0.009		0.014	
	Number			6		9	
Hg*	Mean	3.2	‡‡	5.6	0.8	4.0	0.6
	Std. Dev.	2.0		5.5	0.6	2.7	0.2
	Number	24		18	17	20	25

* Mercury concentrations are listed as μg/l

** Three (3) data greater than 1 mg/l were rejected as being nonrepresentative

† Quantity of water sample was not sufficient for the analysis of this metal

†† Below detection for specific metal

‡ Chromium was not measured in the channel sediments

‡‡ Not measured because of sample storage time

Table 30

Summary Statistics for Total Metals (μg/g) for Sediments from the Artificial Habitat Development Site and a Reference Marsh, James River, from July 1975 to January 1977. Channel Data Are Provided as a Comparison

			Artificial Marsh			Reference Marsh	
Parameter	Statistic	James River Channel	July 1975	August 1976	January 1977	August 1976	January 1977
Fe	Mean	40,780	38,710	33,630	36,170	38,530	35,340
	Std. Dev.	8,100	11,870	10,380	8,184	11,950	6,870
	Number	25	16	27	24	25	25
Ca	Mean	4,100	3,030	2,830	3,140	3,310	2,100
	Std. Dev.	674	973	1,440	660	1,250	800
	Number	20	16	7	24	24	24
Mn	Mean	1,100	902	914	887	318	340
	Std. Dev.	204	263	280	180	109	207
	Number	25	16	27	24	25	24
Zn	Mean	240	188	182	190	224	186
	Std. Dev.	55	70	60	50	142	72
	Number	24	16	27	24	25	25
Pb	Mean	62.2	58.2	51.1	57.7	55.3	55.2
	Std. Dev.	14.3	21.9	17.8	17.7	17.5	17.0
	Number	25	16	27	24	25	24
Cr	Mean	*	71.3**	62	40	64	40
	Std. Dev.		0.0	14	9	10	7
	Number		1	20	24	25	25
Cu	Mean	49.0	41.4	40.2	40.9	45.4	41.1
	Std. Dev.	13.8	15.8	13.5	12.7	14.8	10.5
	Number	25	16	27	24	25	24
Ni	Mean	33.5	35.1	29.6	32.4	36.4	42.8
	Std. Dev.	7.5	12.9	9.5	9.1	5.3	3.2
	Number	25	16	27	24	25	24
Cd	Mean	1.32	1.54	1.33	1.46	1.16	1.24
	Std. Dev.	0.56	0.56	0.47	0.43	0.39	0.32
	Number	25	16	27	24	25	25
Hg	Mean	0.52	0.21	0.23	0.23	0.21	0.23
	Std. Dev.	0.17	0.10	0.08	0.08	0.12	0.25
	Number	19	15	27	24	25	25

* Cr was not measured in the James River channel sediments

** One sample from the middle of a core at site AI (Artificial Habitat intertidal location)

Table 31

Summary Statistics for Average Size Parameters for All Sampling Locations at the James River Artificial Habitat Development Site and a Reference Marsh, the James River Channel, and Suspended Sediments

Sample Location	Number of Samples	Mean ϕ Size	ϕ Sorting	Skewness	% Silt	% Clay	Primary Mode ϕ	Secondary Mode ϕ	Third Mode ϕ
Channel Cores (0 - 20 cm) January 1975	10	7.8	2.9	0.13	50.8	44.1	7.4	9.0	4.7
Artificial Habitat	23	7.9	3.0	0.15	49.6	43.4	6.9	8.6	5.0
Reference Marsh	27	9.0	2.9	-0.15	33.1	60.5	6.8	5.3	4.6
Suspended Sediment at Pipe During Active Dredging	8	7.7	2.9	0.22	51.7	40.4	7.2	5.1	
Suspended Sediment at Pipe 3.5 Months After Dredging	7	8.7	2.5	0.05	43.6	55.6	8.5	6.2	

Table 32

Estimates of Clay Mineral Abundances for the Clay and Silt Size Fractions of Sediments from the James River Artificial Habitat Development Site, a Reference Marsh, the James River Channel, and Nearby Cliffs of Tertiary Age on the South Shore, Approximately 3 km Upstream of the Habitat

Location	Size Fraction (μm)	Illite	Expandable Mixed-Layered	Chlorite	Vermiculite	Smectite	Kaolinate	Estimated CEC meq/100 g
Intertidal Reference Marsh (RI)	0.2-2	33	34	<1	<1	0	32	34
	<0.2	18	41	12	14	6	8	59
High Marsh Artificial Habitat (AH)	0.2-2	37	18	20	0	0	22	28
	<0.2	35	15	0	0	1	49	24
Average Channel	<2	41	12	23	10	8	5	45
Cliffs Along River	<2	57	5	8	12	9	9	45
Average CEC Used For Estimates (meq/100 g)		25	65	25	125	105	9	

Table 33

Average Heavy Mineral Percentages* at the James River Artificial Habitat Development Site and a Reference Marsh

Mineral	Percentage at Artificial Habitat	Percentage at Reference Marsh	Relative Stability
Zircon	4	2	
Tourmaline	14	5	Ultrastable
Rutile	Tr**	Tr	
Staurolite	9	1	
Sillimanite	1	2	
Kyanite	9	3	
Andalusite	6	12	Stable
Sphene	1	6	
Monazite	4	Tr	
Epidote	12	19	
Garnet	1	4	Unstable
Hornblende	16	9	Very Unstable
Opaques	24	33	
Fraction of Total Sediment	0.23	0.11	

* These percentages are number percents based on point counts of 0.062-0.125 mm grains denser than 2.9 g/cc. Surface samples from sites AI and AS (July 1975) and RH and RS (January 1977) were used for these counts

** Tr = trace (less than 0.5 percent)

Table 34

Average Cation Exchange Capacities, as meq/100 g NaEC for Unfractionated Total Samples, from the James River Artificial Habitat Development Site and a Reference Marsh for August 1976 and January 1977

Season	Location	Statistic (n=3)*	Artificial Habitat (0-10 cm)	Artificial Habitat (24-50 cm)	Reference Marsh (0-10 cm)	Reference Marsh (24-50 cm)
Summer	High Marsh	Mean	6.0	9.9	88.8	61.5
	(AH & RH)	Std. Dev.	1.0	2.4	5.2	4.3
	Intertidal Marsh	Mean	46.6	33.0	52.1	48.6
	(AI & RI)	Std. Dev.	4.8	3.4	8.3	8.8
	Subtidal Marsh	Mean	43.9	43.3	60.6	65.0
	(AS & RS)	Std. Dev.	2.1	1.9	1.2	3.4
	All Summer	Mean	32.2	28.7	67.2	58.4
	Samples	Std. Dev.	19.8	15.0	17.3	9.1
Winter	High Marsh	Mean	20.7	19.6	96.0	47.4
	(AH & RH)	Std. Dev.	3.1	6.6	30.9	3.6
	Intertidal Marsh	Mean	38.1	33.5	57.0	41.3
	(AI & RI)	Std. Dev.	1.8	1.7	12.4	5.1
	Subtidal Marsh	Mean	41.1	38.9	50.6	58.9
	(AS & RS)	Std. Dev.	8.1	4.3	8.1	10.7
	All Winter	Mean	32.9	29.9	64.6	49.9
	Samples	Std. Dev.	10.6	9.8	25.5	10.7

* The three samples were from separate cores taken within a 25 m^2 area, and each sample was analyzed in duplicate.

Table 35

Variations in Sediment CEC with Various Size Fractions, Freeze-Drying, and Saturating Ions from the Same Samples Collected in July 1975 or July 1976 at the James River Artificial Habitat Development Site

Treatment	Mean meg/100 g	Std. Dev. meg/100 g	n	Change with Respect To First Line (%) Mean	Std. Dev.
Bulk, Wet, NaEC	33.2	4.2	5	—	—
<2μm, Wet, NaEC	65.7	25.3	3	+80	59
<2μm, Freeze-Dried CaEC	35.2	11.0	6	+10	45
<62μm, Wet, NaEC	33.7	5.7	12	- 8	13
<62μm, Freeze-Dried NaEC	22.9	2.6	6	-30	14

Table 36

Temporal Changes in Cation Exchange Capacity, as meq/100 g NaEC for Selected Samples, from the James River Artificial Habitat Development Site

Size Fraction	Date of Collection	Statistic	Sample Location (x,y) (100,400)*	(100,300)	(225,125)	(200,300)	(1100,100)
Total	July 1975	Mean	—	29.0	32.6	—	38.1
		Std. Dev.		3.2	1.8		—
		Number		2	2		1
<62μm	July 1975	Mean	—	28.2	34.0	—	29.8
		Std. Dev.		0.1	1.2		3.3
		Number		2	2		2
<62μm	July 1976	Mean	41.5	41.3	49.8	44.9	34.5
		Std. Dev.	1.3	2.5	—	5.4	3.3
		Number	2	2	1	2	4
Total	August 1976	Mean	6.0	—	—	46.6	43.9
		Std. Dev.	1.0			4.8	2.1
		Number	3			3	3
Total	January 1977	Mean	20.7	—	—	38.1	41.1
		Std. Dev.	3.1			1.8	8.1
		Number	3			3	3
Total	June 1977	Mean	—	—	—	29.3	30.2
		Std. Dev.				2.3	1.3
		Number				2	2

* Bulk samples from AH (high marsh site) contained variable amounts of sand which reduced the CEC proportionately to the percent of sand

Table 37

Summary Statistics for the Change in Cation Exchange Capacity, as meq/100 g NaEC with Removal of Organic Matter and Iron Coatings, for Sediments from the James River Artificial Habitat Development Site and a Reference Marsh

Size Fraction	Marsh	Collection Date	Statistic	Untreated Wet	Organics Removed	Δ%	Organic Matter and Iron Coatings Removed	Δ%
<62μm	Habitat	July 1975	Mean	30.4	19.1	-36.5	19.8*	-34.0
			Std. Dev.	2.9	2.5	11.4	3.2	14.8
			Number	6	6	6	6	6
<62μm	Habitat	July 1976	Mean	37.1	29.6	-27.2	21.8	-40.4
			Std. Dev.	6.9	3.8	11.0	1.6	7.1
			Number	6	4	4	6	6
Total	Habitat	Jan 1977	Mean	34.6	15.0	-61.4	13.7	-60.3
			Std. Dev.	9.4	3.9	4.4	3.5	2.4
			Number	10	10	10	10	10
Total	Reference Marsh	Jan 1977	Mean	62.4	22.8	-60.8	21.3	-63.2
			Std. Dev.	27.7	4.4	9.4	4.2	9.4
			Number	12	12	12	12	12

* Iron coatings only removed

Table 38

Concentrations and Average Percentages of Metals Associated with Different Fractions of the Sediments from the James River Artificial Habitat Development Site and a Reference Marsh

(Data are from Nivens (1978) for Cores Collected in August 1976)

	IRON		CALCIUM		MANGANESE		ZINC		LEAD		COPPER		NICKEL	
Fractions	Art*	Ref*	Art	Ref	Art	Ref	Art	Ref	Art	Ref	Art	Ref	Art	Ref
Interstitial water (mg/l)	22.8 (16.7)**	22.7 (21.4)	78.1 (33.2)	21.2 (15.3)	3.74 (1.94)	1.56 (1.46)	0.060 (0.034)	0.067 (0.038)	BD†	BD	BD	BD	BD	BD
Exchangeable (%)	0.26 (0.44)	0.44 (0.93)	40.4 (11.2)	68.6 (27.0)	18.1 (12.8)	29.6 (14.0)	7.56 (9.54)	8.56 (8.25)	BD	BD	BD	BD	BD	BD
Easily reducible (%)	5.34 (2.64)	5.52 (3.98)	17.6 (6.15)	11.1 (4.59)	44.8 (11.6)	24.6 (37.8)	25.1 (11.6)	19.6 (20.2)	BD	BD	11.7 (9.43)	6.86 (7.75)	4.22 (6.42)	1.07 (2.19)
Organic (%)	2.27 (2.19)	3.16 (1.57)	8.03 (3.76)	7.48 (3.50)	16.2 (8.78)	12.7 (10.6)	12.0 (17.8)	14.1 (11.2)	7.43 (6.20)	4.99 (6.77)	11.2 (8.54)	17.7 (10.2)	8.85 (7.62)	9.83 (7.30)
Moderately reducible (%)	46.51 (16.0)	46.3 (21.4)	0.90 (0.59)	0.413 (0.312)	8.59 (1.50)	11.1 (10.5)	15.6 (4.58)	14.3 (4.21)	33.7 (12.3)	38.6 (21.5)	BD	BD	BD	BD
Residual (%)	45.6 (9.92)	44.8 (4.67)	33.1 (16.8)	12.4 (4.96)	12.2 (3.29)	22.0 (5.69)	39.8 (12.8)	43.4 (12.3)	58.8 (16.9)	56.4 (14.8)	77.1 (32.0)	75.4 (21.1)	86.9 (26.0)	89.1 (11.2)
Total by summation (μg/g)	33,800 (9,400)	36,400 (8,900)	3089	2420	745 (187)	320 (195)	208	225	49.8	51.3	40.6 (14.4)	42.8 (13.5)	31.8 (9.81)	42.3 (4.01)
Total by bulk analysis (μg/g)	34,500 (7,690)	37,300 (11,500)	2979 (654)	2900 (966)	888 (174)	388 (231)	187 (46.4)	197 (100)	52.2 (14.2)	51.8 (18.1)	40.4 (10.2)	42.1 (14.0)	30.0 (7.89)	39.0 (5.68)

* Art = Artificial Habitat Development Site; Ref = Reference Marsh near Ducking Stool Point

** ±1 sigma, expressed in designated units (mg/l, %, or μg/g)

† BD = Below detection for specified metal

Fractions or phases defined as:

Interstitial - by centrifugation (in nitrogen atmosphere)
Exchangeable - removed from cation exchange sites by NH_4OAc leach (in nitrogen atmosphere)
Easily reducible - extract hydrous manganese oxides and hydroxides with $NH_2OH \cdot HCl$
Organic - digestion with 30% H_2O_2 at 95°C at 2.5 pH
Moderately reducible - extraction if hydrous iron oxides with citrate-dithionite
Residual - digestion with HF, HNO_3 and fuming HNO_3 at 95°C

Table 39

Abundances of Calcium, Iron, Manganese, and Zinc Associated with the Exchangeable Phase of Sediments Collected from the James River Artificial Habitat Development Site and a Reference Marsh in August 1976 and January 1977. Units are in meq/100 g*

	Metal	Mean	Std. Dev.	Range
Artificial Habitat	Ca	6.22	1.73	3.20 - 8.70
	Fe	0.348	0.576	BD** - 1.58
	Mn	0.492	0.346	0.004- 1.16
	Zn	0.048	0.048	0.015- 0.216
	Sum	7.11		
Reference Marsh	Ca	8.29	3.26	3.30 -14.10
	Fe	0.724	1.21	BD** - 3.98
	Mn	0.337	0.159	0.100- 0.585
	Zn	0.059	0.057	0.006- 0.175
	Sum	9.41		

* Sum of Cd, Cr, Cu, Hg, Ni, and Pb combined represented less than 0.1 meq/100 g base exchange

** BD = Below detection

Table 40

Summary Statistics for Vane Shear and Water Content Measurements at the James River Artificial Habitat Development Site and a Reference Marsh During the Entire Program from July 1975 to January 1977

Location	Depth cm	Undisturbed $g/cm^2 \pm$ S.D.	Remolded $g/cm^2 \pm$ S.D.	Water Content % ± S.D.
Artificial Habitat	4	——	——	43 ± 19
July 1975	23	57 ± 55	15 ± 11	39 ± 13
(n = 26)	53	57 ± 44	15 ± 10	41 ± 9
	83	49 ± 33	13 ± 8	46 ± 8
	114	60 ± 44	16 ± 8	45 ± 6
	140	65 ± 44	16 ± 9	43 ± 0
Reference Marsh	5	——	——	64 ± 8
August 1976	23	78 ± 64	13 ± 8	59 ± 3
(n = 3)	53	62 ± 41	10 ± 4	61 ± 15
	80	81 ± 28	11 ± 3	——
Artificial Habitat	6*	80 ± 51	10 ± 7	49 ± 11
January 1977	23	73 ± 38	15 ± 7	31 ± 12
(n = 13)	53	83 ± 37	21 ± 7	——
	83	80 ± 35	18 ± 5	46 ± 3
Reference Marsh	6*	66 ± 47	15 ± 12	76 ± 6
January 1977	23	81 ± 42	12 ± 7	60 ± 4
(n = 2)	53	115 ± 24	17 ± 6	56 ± 9
	83	103 ± 16	19 ± 9	65 ± 6

* Surface was frozen; therefore, these shear strengths are questionable

Table 41

Relative Composition of Metals Between the Dissolved Interstitial Water And Total Sediment Phases. Calculations Were for the James River Channel Cores Only

Metal	Total Phase Concentration (μg/g)	Interstitial Water Concentration (mg/l)*	Total Phase Divided by Interstitial	Interstitial as Percentage of Total (%)
Iron	40,780	57.2	713	0.14
Calcium	4,100	215.9	19	5.3
Manganese	1,100	6.94	158	0.63
Zinc	240	0.12**	2,000	0.05
Lead	62.3	0.077	809	0.12
Chromium	62†	0.034†	1,820	0.05
Copper	49.0	0.010	4,900	0.02
Nickel	33.5	0.054	620	0.16
Cadmium	1.32	0.009	147	0.68
Mercury	0.52	0.0032	162	0.62
			Mean 1,130	0.78
			Range (19 - 4,900)	(0.02 - 5.3)

* These concentrations were about two percent greater than ppm by weight because the density of water was not equal to one

** Three values greater than 1 mg/l were not included because they were suspected of being contaminated

† August 1976 data were used because only one analysis was made from July 1975 samples at the Habitat (see Table 30)

AD-A062 841 OLD DOMINION UNIV NORFOLK VA F/G 13/2
HABITAT DEVELOPMENT FIELD INVESTIGATIONS WINDMILL POINT MARSH D--ETC(U)
AUG 78 D D ADAMS, D A DARBY, R J YOUNG DACW65-75-C-0051

UNCLASSIFIED WES-TR-D-77-23-APP-F-VOL-2 NL

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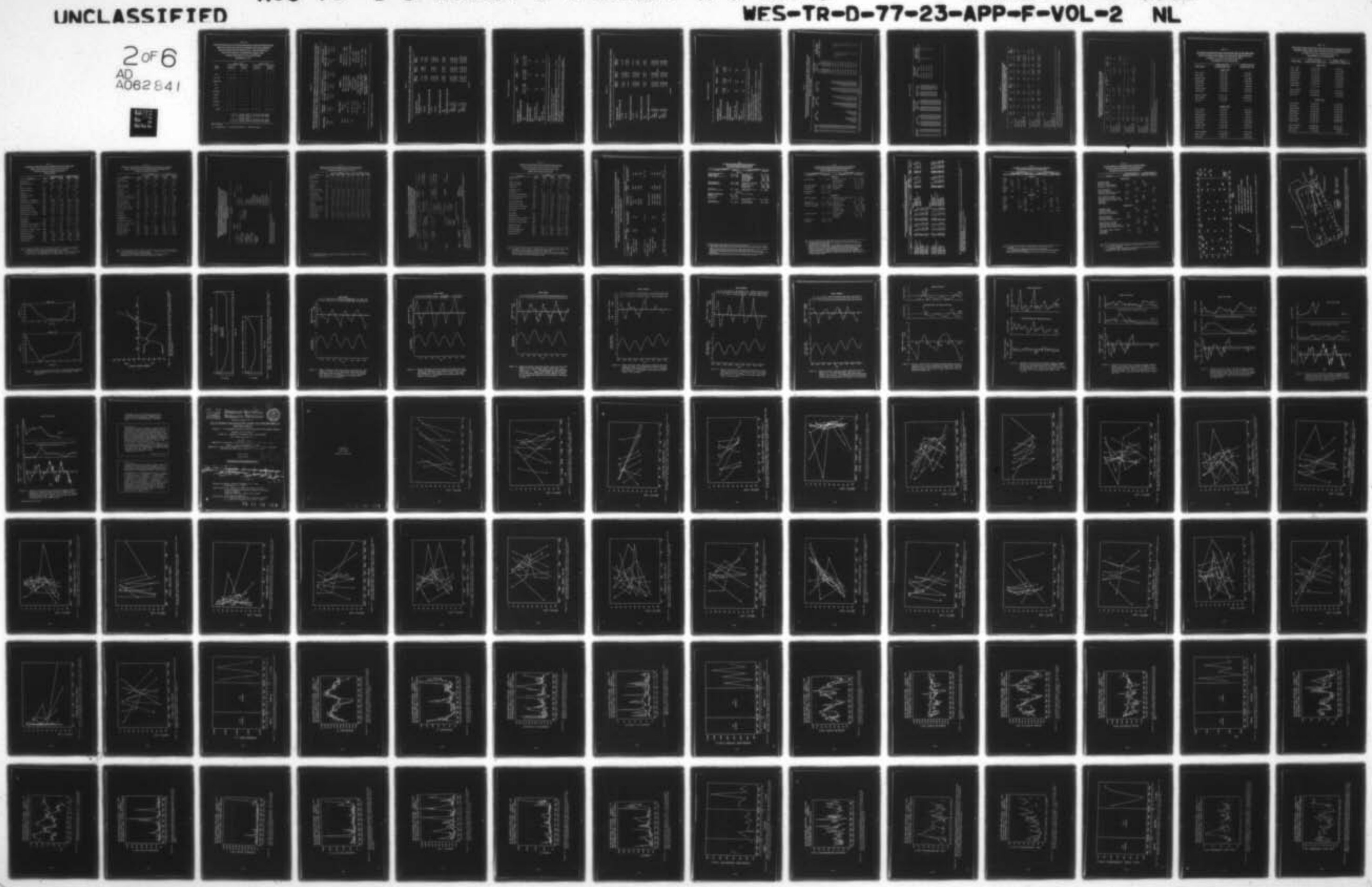
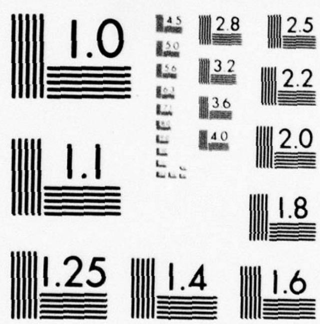




MICROCOPY RESOLUTION TEST CHART

Table 42

Trends with Depth for Total Metals Analyzed in Cores Collected from the James River Artificial Habitat Development Site and a Reference Marsh in August 1976 and January 1977. Code and Numerical Values Are Constant or Insignificant Change (=,0), Increase with Depth (+, +1), and Decrease with Depth (-, -1)

Total Metal	August 1976						January 1977					
	Artificial Habitat			Reference Marsh			Artificial Habitat			Reference Marsh		
	H	I	S	H	I	S	H	I	S	H	I	S
Iron	+	=	+	=	+	+	+	=	=	+	-	-
Calcium	+	ND	ND	=	-	=	+	=	=	-	-	-
Manganese	+	=	+	=	+	-	+	=	+	=	=	-
Zinc	+	=	=	-	-	=	+	=	=	-	-	-
Lead	+	-	=	-	-	-	=	=	+	-	-	-
Chromium	=	=	=	=	=	=	+	=	=	=	=	-
Copper	+	=	=	=	=	-	+	=	=	-	-	-
Nickel	+	=	=	+	=	=	=	=	=	+	=	=
Cadmium	+	=	-	=	-	=	+	=	=	-	-	-
Mercury	+	=	=	-	=	=	-	=	+	+	-	-
Trend	9	-1	1	-2	-2	-2	6	0	3	-2	-7	-9

6 to 10 = Strong trend to increase with depth
1 to 5 = Slight trend to increase with depth
0 = No net trend
-1 to -5 = Slight trend to decrease with depth
-5 to -9 = Strong trend to decrease with depth

ND = No data

H = High marsh, I = Intertidal Marsh, S = Subtidal Marsh

Table 43

Variations in the Atomic C:N:P Ratios in Sediments at the James River Artificial Habitat Development Site and a Reference Marsh. Channel Sediments and Literature Values Are Provided for Comparison

Atomic Ratios	James River Channel	Artificial Habitat			Reference Marsh	
		July 1975	August 1976	January 1977	August 1976	January 1977
C:N:P	—*	56:9.5:1	37:2.3:1	47:1.8:1	48:5.3:1	53:3.6:1
N:P	13.8:1	9.5:1	2.3:1	1.8:1	5.3:1	3.6:1
C:N	—*	5.9:1	15.9:1	26.8:1	9:1	14.8:1

	Atomic Ratios	Comments	References
C:N:P	106:16:1	Open ocean plankton	Redfield et al. (1963)
C:N	6.6:1	Open ocean plankton	Redfield et al. (1963)
N:P	10:1 to 19:1	James River channel sediments	(from Table 3 in Volume 1)
C:N	7.3:1 to 12.4:1	Wisconsin lakes	Keeney (1972)
	9:1 to 15:1	Lake sediments	Goering (1972)
	9.3:1 to 12.6:1	Ocean sediments, Soils	Salomon (1962)
	9.5:1	Suspended organic material in Narragansett Bay	Oviatt and Nixon (1975)
	55:1 to 60:1	Dead creek bank *Spartina alterniflora* in winter	Nixon et al. (1976b)

* Channel sediments not analyzed for TOC

Table 44

Weather and Tidal Data During the August 5-7, 1976 Sampling Program, James River, Virginia

		August 5	August 6	August 7
Sunrise/Sunset (EDT)		0613/2008	0614/2007	0615/2006
Tide Gauge* (ht, ft)/(time, EDT)				
Low Tide		1.1/1745	1.3/0646 0.9/1845	1.0/0800
High Tide		3.3/1100	3.1/1200	3.7/0130
		3.9/2400		3.0/1318
NOAA Tide Tables** (ht, ft)/(time, EDT)				
Low Tide		0.2/0533	0.2/0639	0.1/0737
		0.1/1736	0.1/1840	0.0/1940
High Tide		2.1/1106	2.1/1237	2.8/0047
		2.7/2346		2.3/1313
Field Air Temperature (°C)/(time, EDT)				
Low		21.6/0945	20.4/0345	21.5/0445
High		30.3/1605	36.5/1455	23.0/0815
Field Water Temperature (°C)/(time, EDT)				
Low Tidal Channel Location†	AP	23.2/0720	21.7/0621	22.7/0750
	AB	23.2/0720	22.8/0447	22.9/0620
	RL	25.4/0840	25.0/0745	25.6/0545
	RS	25.4/0755	25.1/0845	24.8/0655
High Tidal Channel Location†	AP	28.4/1610	29.3/1200	25.2/0305††
	AB	29.6/1555	29.0/1530	25.8/0245††
	RL	28.2/1345	29.6/1345	26.7/0045††
	RS	27.7/1545	28.2/1400	26.7/0050††

(continued)

Table 44 (Concluded)

	August 5	August 6	August 7
Climatological Data‡			
Air Temperature (°C)/(time, EDT)‡‡			
Low	(15.6) 14.4/0400	(18.3) 17.8/0400	(20.6) 21.1/0400
High	(32.2) 32.2/1600	(35.0) 35.0/1400	(34.4) 32.2/1300
Average Relative Humidity (%)	66	60	71
Precipitation (inches)	0	0	0
Wind			
Average Velocity (mph)	5.3	7.1	6.0
Resultant Direction (degrees)	200	200	170
Sunshine			
Duration (min)	599	674	262
Percent of Possible Total	71	81	31

* Field tide gauge information at Belcher's Wharf was supplied by WES representative (see Figure 1 for location)

** Tidal information for Windmill Point, James River, VA

† See Figures 2 and 3 for station locations

†† Maximum temperature recorded during the sample period, which ended 0900 EDT, August 7. The daily maximum temperature would be reached in the afternoon

‡ At R.E. Byrd International Airport, Richmond, VA, approximately 37 km northwest of the Artificial Habitat Development Site

‡‡ Times are approximate, based on observations at 3-hour intervals at Byrd Airport. Air temperature (15.6) recorded in Hopewell at Va. American Water Co. were 24-hr minimum and maximum temperatures only

Table 45

Weather and Tidal Data During the January 8-10, 1977 Sampling Program, James River, Virginia

		January 8	January 9	January 10
Sunrise/Sunset (EST)		0714/1655	0713/1655	0713/1656
Tide Gauge* (ht, ft)/(time, EST)				
Low Tide		1.25/1052	0.79/1052	1.91/1208
		0.77/2322	1.64/2315	
High Tide			2.74/0452	4.05/0545
		3.18/1630	3.47/1738	3.15/1700
NOAA Tide Tables** (ht, ft)/(time, EST)				
Low Tide		-0.4/1021	-0.3/1106	-0.3/1154
		-0.4/2258	-0.4/2338	
High Tide		1.9/0356	2.0/0437	2.0/0524
		2.3/1614	2.2/1656	2.1/1742
Field Air Temperature (°C)/(time, EST)				
Low		-1.4/1750	-6.0/0730	±1.0/0700
High		5.5/1430	2.4/1230	6.5/1130
Field Water Temperature (°C)/(time, EST)				
Low				
Tidal Channel Location†	AP	-0.4/1935	-0.2/0015	0.4/0630
	AB	-0.2/2110	-0.1/0205	0.4/0650
	RL	-0.5/1221	0.2/0030	0.4/1000
	RS	0.0/1250	0.0/0010,2030	0.3/1000
High				
Tidal Channel Location†	AP	3.5/1340	3.3/1315	4.2/1245
	AB	3.4/1310	2.4/1130	4.4/1300
	RL	1.5/1530	1.0/1230	1.8/0430
	RS	1.4/1640	1.0/1200	2.0/1600

(continued)

Table 45 (Concluded)

	January 8	January 9	January 10
Climatological Data††			
Air Temperature (°C)/(time, EST)‡			
Low	-12.8/0800	-9.4/0500	-7.8/2300
High	1.7/1700	0.6/1600	6.1/1700
Average Relative Humidity (%)	62	83	81
Precipitation (inches)	0	0.32‡‡	0.51
Wind			
Average Velocity (mph)	4.6	5.0	11.8
Resultant Direction (degrees)	350	080	260
Sunshine			
Duration (min)	512	003	121
Percent of Possible Total	88	1	21

* Field tide gauge information at Belcher's Wharf was supplied by WES representative (see Figure 1 for location)

** Tidal information for Windmill Point, James River, VA

† See Figures 2 and 3 for station locations

†† At R.E. Byrd International Airport, Richmond, VA., approximately 37 km northwest of the Artificial Habitat Development Site

‡ Times are approximate, based on observations at 3-hour intervals

‡‡ Water equivalent in inches (1.7 inches of snow was recorded) with conversion by U.S. Weather Service

Table 46

Cumulative Surface Area Tidal Inundation at the James River Artificial Habitat Development Site and a Natural Reference Marsh Near Ducking Stool Point from Topographic Surveys in 1976 and 1977*

(See Figure 1 for Locations)

Tidal Height		ARTIFICIAL HABITAT July 1975		ARTIFICIAL HABITAT April 1976		ARTIFICIAL HABITAT March-April 1977		REFERENCE MARSH August 1977		REFERENCE MARSH/ ARTIFICIAL HABITAT	
(ft)	(m)	(ft^2)	(m^2)	(ft^2)	(m^2)	(ft^2)	(m^2)	(ft^2)	(m^2)	April 1976	Mar-April 1977
-1.0	-0.305							29,137	2,706.9		
0.0	0.000							123,788	11,500.3		
0.2	0.061							158,974	14,769.3		
0.4	0.122							200,628	18,639.0		
0.6	0.183							255,289	23,717.2		
0.8	0.244							357,200	33,185.1		
1.0	0.305							447,273	41,553.2		
1.2	0.366							653,166	60,681.3		
1.3	0.396					75	7.0				
1.4	0.427					450	41.8	862,075	80,089.7		1,900.0
1.5	0.457			50	4.6	1,000	92.9				
1.6	0.488			100	9.3	2,600	241.5	1,022,369	94,981.6	10,200.0	393.0
1.7	0.305			300	27.9	2,975	276.4				
1.8	0.549			500	46.5	9,500	882.6	1,154,288	107,237.3	2,300.0	121.0
1.9	0.579			1,025	95.2	26,725	2,482.8				
2.0	0.610			1,925	178.8	62,400	5,797.2	1,252,995	116,407.5	650.0	20.0
2.1	0.640			7,800	724.6	94,875	8,814.2				
2.2	0.671			22,750	2,113.6	149,550	13,893.7	1,322,552	122,869.6	58.0	8.8
2.3	0.701			51,850	4,817.0	198,200	18,413.5				
2.4	0.732			88,550	8,226.6	235,800	21,906.6	1,395,505	129,647.1	16.0	5.9
2.5	0.762	25	2.3	126,075	11,712.8	267,175	24,821.5				
2.6	0.793	100	9.3	188,675	17,528.5	292,150	27,141.7	1,448,132	134,536.4	7.7	5.0
2.7	0.823	625	58.1	236,850	22,004.2	319,750	29,705.9				
2.8	0.854	2,750	255.5	265,800	24,693.7	339,425	31,533.7	1,487,646	138,207.4	5.6	4.4
2.9	0.884	6,875	638.7	291,500	27,081.3	358,325	33,289.6				
3.0	0.915	52,450	4,872.8	319,975	29,726.8	371,625	34,525.2	1,519,451	141,163.2	4.7	4.1
3.1	0.945	147,675	13,719.5	339,975	31,584.8	383,075	35,589.0				
3.2	0.976	207,250	19,254.2	359,650	33,412.7	394,900	36,687.5	1,539,247	143,001.2	4.3	3.9
3.3	1.006	237,500	22,064.6	375,300	34,866.6	404,100	37,542.3				

(Continued)

* Surveys at Artificial Habitat in July 1975, April, 1976, and March through April 1977.

Table 46 (Concluded)

Tidal Height		Artificial Habitat						Reference Marsh		Reference Marsh/ Artificial Habitat	
		July 1975		April 1976		March-April 1977		August 1977			
(ft)	(m)	(ft^2)	(m^2)	(ft^2)	(m^2)	(ft^2)	(m^2)	(ft^2)	(m^2)	April 1976	Mar-April 1977
3.4	1.037	271,250	25,200.0	392,050	36,422.8	410,000	38,090.4	1,566,712	145,552.8	4.0	3.8
3.5	1.067	302,900	28,140.4	404,300	37,560.8	416,625	38,705.9				
3.6	1.098	325,325	30,223.8	413,150	38,383.0	422,075	39,212.2	1,584,308	147,187.6	3.8	3.8
3.7	1.128	344,275	31,984.3	419,450	38,968.3	426,425	39,616.3				
3.8	1.158	357,100	33,175.8	424,875	39,472.3	430,275	39,974.0	1,596,016	148,275.3	3.8	3.7
3.9	1.189	365,500	33,956.2	427,700	39,734.8	432,750	40,203.9				
4.0	1.219	377,875	35,105.9	429,525	39,904.3	434,650	40,380.5	1,604,004	149,017.5	3.7	3.7
4.1	1.250	397,825	36,959.3	431,850	40,120.3	437,300	40,626.7				
4.2	1.280	420,350	39,051.9	433,850	40,306.3	440,150	40,891.4	1,615,996**	150,131.5**	3.7	3.6
4.3	1.311	430,350	39,981.0	436,625	40,563.9	441,675	41,033.1				
4.4	1.341	437,975	40,689.4	437,675	40,661.5	442,525	41,112.1				
4.5	1.372	442,575	41,116.7	438,450	40,733.5	443,400	41,193.4				
4.6	1.402	443,625	41,214.3	439,000	40,784.6	443,750	41,225.9				
4.7	1.433	444,125	41,260.7	439,425	40,824.1						
4.8	1.463	444,525	41,297.9	439,700	40,849.6						
4.9	1.494	444,725	41,316.5	439,750	40,854.3						

** Cumulative surface area for tidal inundation at 4.2 ft. and greater

Table 47

Protocol for Compositing Hourly Water Samples Collected from the James River Artificial Habitat Development Site and Reference Marsh During August 5-7, 1976 Sampling Period. Sample Numbers Are Listed According to Collection Times Shown in Figures 13, 14, and 15

Site	Low Slack	Flood	High Slack	Ebb	Pore Water Drainage**	Low Slack	Flood	High Slack	Ebb	Pore Water Drainage**
	1*	2	3	4	5	6	7	8	9	10
Artificial Marsh										
Pipe (AP)	1	2,3	4	6,7,8,9	10,11	12,13	15,16	17	18,19,20,21	22,23
Breach (AB)	---†	2,3	4	6,7,8	---	---†	15,16	17	18,19,20,21	---
Reference Marsh										
Large Channel (RL)	---	1,2	4,5	7,8,9	---	10,11	13,14,15	16,17,18	19,20,21,22	---
Small Channel (RS)	---	1,2	4,5	7,8,9	---	10,11	13,14,15	16,17,18	19,20,21,22	---
	11	12	13	14	15	16	17	18	19	20
Artificial Marsh										
Pipe (AP)	24,25	26,27	28,29_1††	29_2††,30	33	34	35,36,37,38	39	40,41,42	43,44,45
Breach (AB)	---†	25,26,27	28	31	---	---†	36,37,38	39,40	41,42	---
Reference Marsh										
Large Channel (RL)	23,24,25	26,27	29,30	31,32,33,34	---	35,36	37,38,39	41,42,43	45,46,47,48	---
Small Channel (RS)	23,24,25	26,27	29,30	31,32,33	---	34	37,38,39	41,42,43	45,46,47,48	---
	21									
Artificial Marsh										
Pipe (AP)	---									
Breach (AB)	---†									
Reference Marsh										
Large Channel (RL)	49									
Small Channel (RS)	49									

* Numbering system for composite samples (total of 21).

** Period of low slack tide when water was still draining from the Artificial Habitat marsh. Substantial drainage only occurred through the pipe.

† During low slack water the the Artificial Habitat breach (site AB) was dry.

†† Error during shift change in the field.

Table 48

Protocol for Compositing Hourly Water Samples Collected from the James River Artificial Habitat Development Site and Reference Marsh During the January 8-10, 1977 Sampling Period. Sample Numbers Are Listed According to the Collection Times Shown in Figures 16, 17, and 18

Site	Flood	High Slack	Ebb	Pore Water Drainage**	Low Slack	Flood	High Slack	Pre-precipitational Ebb†	Ebb	Pore Water Drainage**	Low Slack
	1*	2	3	4	5	6	7		8	9	10
Artificial Marsh											
Pipe (AP)	1,2,3	4	5,6,7,8	9,10	11	12,13,14,15	---		16,17,18,19,20	21	22
Breach (AB)	1,2,3	4	5,6,7	---	---††	14,15	---		16,17,18	---	---††
Reference Marsh											
Large Channel (RL)	1,2,3,4	5,6	7,8,9,10,11	---	12	13,14,15,16,17	18		19,20,21	---	22,23,24
Small Channel (RS)	1,2,3,4	5,6	7,8,9,10,11	---	12	13,14,15,16,17	---		18,19,20	---	21,22,23,24
	11	12	13	14	15	16	17	18	19	20	21
Artificial Marsh											
Pipe (AP)	23,24,25	26,27	28,29	30	31	32,33,34,35	37,38	---	39,40,41	42	43
Breach (AB)	23,24,25,26	27	28,29	---	---††	33,34,35,36	---	38,39,40,41	---	---	---††
Reference Marsh											
Large Channel (RL)	26,27,28	30,31	32,33,34	---	---	36,37,38,39	---	40,41,42,43	44,45,46,47,48	---	---
Small Channel (RS)	25,26,27,28	30	31,32,33,34,35	---	---	36,37,38,39	---	40,41,42	43,44,45,46,47,48	---	---
	22										
Artificial Marsh											
Pipe (AP)	45,46,47										
Breach (AB)	45,46,47										
Reference Marsh											
Large Channel (RL)	50,51,52,53										
Small Channel (RS)	49,50,51,52,53										

* Numbering system for composite samples (total of 22).

** Period of low slack tide when water was still draining from the Artificial Habitat marsh. Substantial drainage only occurred through the pipe.

† Because of rain and wind conditions, an early ebb tide occurred.

†† During low slack water the Artificial Habitat breach (site AB) was dry.

Table 49

Total Water Volume During Each Flood and Ebb Tide at the James River Artificial Habitat Development Site During the Sampling Periods of August 5-7, 1976 and January 8-10, 1977. See Appendix D' for Calculations

Tidal Stage	Volume (liters) Through Breach (AB)	Volume (liters) Through Pipes (AP)
	August 1976	
First Flood	1,600,298	1,602,005
First Ebb	3,213,442	1,767,767
Second Flood	7,138,625	421,898
Second Ebb	6,133,474	6,026,950
Third Flood	3,252,689	640,192
Third Ebb	2,067,795	832,939
Fourth Flood	7,439,605	3,165,708
Fourth Ebb	2,337,695	4,875,092
Sum of Floods	19,431,217	5,829,803
Sum of Ebbs	13,752,406	13,502,748
Net Flux	5,678,811	- 7,672,945
	January 1977	
First Flood	7,029,657	1,228,596
First Ebb	5,143,276	3,496,855
Second Flood	3,488,037	350,707
Second Ebb	3,367,415	1,232,623
Third Flood	8,972,507	1,908,549
Third Ebb	7,342,947	4,282,389
Fourth Flood	13,631,845	4,548,451
Fourth Ebb	14,265,293	4,491,404
Sum of Floods	33,122,046	8,036,303
Sum of Ebbs	30,118,931	13,503,271
Net Flux	3,003,115	- 5,466,968

Table 50

Total Water Volume During Each Flood and Ebb Tide at Ducking Stool Point Reference Marsh, James River, Virginia, During the Sampling Periods of August 5-7, 1976 and January 8-10, 1977. See Appendix D' for Calculations

Tidal Stage	Volume (liters) Through Large Channel (RL)	Volume (liters) Through Small Channel (RS)
	August 1976	
First Flood	19,579,456	10,094,617
First Ebb	29,581,270	14,110,384
Second Flood	41,275,235	21,447,922
Second Ebb	48,528,085	24,247,421
Third Flood	21,914,393	11,160,048
Third Ebb	37,188,995	14,663,791
Fourth Flood	40,472,979	22,522,891
Fourth Ebb	37,811,902	17,416,471
Sum of Floods	123,242,063	65,225,478
Sum of Ebbs	153,110,252	70,438,067
Net Flux	- 29,868,189	- 5,212,589
	January 1977	
First Flood	33,905,741	17,590,826
First Ebb	42,538,107	18,957,527
Second Flood	37,441,388	18,167,365
Second Ebb	28,238,486	13,927,078
Third Flood	36,468,915	23,991,574
Third Ebb	37,858,734	22,492,856
Fourth Flood	44,765,052	25,704,423
Fourth Ebb	51,051,265	29,811,879
Sum of Floods	152,581,096	85,454,188
Sum of Ebbs	159,686,592	85,189,340
Net Flux	- 7,105,496	264,848

Table 51

Comparisons of Mean Water Quality Parameter Values for August 1970 (Summer) and January 1977 (Winter) at the James River Artificial Habitat Development Site and the Reference Marsh

Parameter	Units	Development Site Summer		Development Site Winter	Reference Marsh Summer		Reference Marsh Winter
Conductivity	mmho/cm	0.175	=	0.179	0.165	>	0.106
Water temperature	°C	26.0	>	1.1	26.7	>	0.7
pH		7.18	≤	7.40	7.32	<	8.00
Dissolved oxygen	mg/ℓ	5.71	<	11.44	6.94	<	12.29
Oxygen saturation	°/o	53	<	82	86	=	87
Alkalinity	meq/ℓ	--		0.49	--		0.39
Suspended solids*	mg/ℓ	86	≥	54	25	=	27
Turbidity	FTU	35	≥	22	16	≥	11
Dissolved orthophosphate	mg/ℓ	0.082	>	0.045	0.041	=	0.033
Dissolved total phosphorus	mg/ℓ	0.092	≤	0.114	0.084	≤	0.099
Total phosphorus	mg/ℓ	0.235	=	0.234	0.155	<	0.181
Dissolved ammonium	mg/ℓ	0.47	=	0.47	0.47	=	0.46
Dissolved NO_3 + NO_2	mg/ℓ	0.619	<	1.95	0.524	<	1.61
Dissolved total nitrogen	mg/ℓ	3.48	>	2.60	1.76	<	2.53
Total Kjeldahl nitrogen	mg/ℓ	5.25	>	3.07	4.23	>	3.29
Fo/Fa ratio		1.71	>	1.44	1.75	>	1.52
Chlorophyll	μg/ℓ	10.24	>	1.09	13.88	>	0.81
Phaeophytin	μg/ℓ	4.36	>	1.67	5.23	>	0.78
Dissolved volatile organic C	mg/ℓ	2.6	=	2.1	1.4	=	1.3
Dissolved total organic C	mg/ℓ	9.8	=	9.2	8.8	=	9.1
Particulate organic carbon	mg/ℓ	--		2.79	--		1.47
Dissolved calcium	mg/ℓ	16.3	>	13.5	13.7	>	11.6
Dissolved iron	mg/ℓ	0.489	>	0.281	0.269	=	0.299
Dissolved manganese	mg/ℓ	0.184	>	0.061	0.046	>	0.029
Dissolved mercury	μg/ℓ	0.61	>	0.31	0.61	>	0.28
Dissolved zinc	mg/ℓ	0.088	≥	0.067	0.078	≥	0.048

Note: > indicates greater than; = indicates equal to; < indicates less than. Differences are not necessarily statistically significant.

* At the pipe of the experimental site summer values > winter values, while at the breach of the experimental site summer values ≥ winter values.

Table 52

Comparisons of Water Quality Parameter Values for the James River Artificial Habitat Development Site and the Reference Marsh During August 1976 (Summer) and January 1977 (Winter)

Parameter	Units	Summer Development Site		Summer Reference Marsh	Winter Development Site		Winter Reference Marsh
Conductivity*	mmho/cm	0.175	≥	0.165	0.179	>	0.106
Water temperature	°C	26.0	=	26.7	1.1*	≥	0.7*
pH*		7.18	<	7.32	7.40	<	8.00
Dissolved oxygen*	mg/ℓ	5.71	<	6.94	11.44	<	12.29
Oxygen saturation*	°/o	53	<	86	82	≤	87
Alkalinity	meq/ℓ	--		--	0.49*	>	0.39*
Suspended solids	mg/ℓ	86*	>	25*	54	>	27
Turbidity*	FTU	35	>	16	22	>	11
Dissolved orthophosphate *	mg/ℓ	0.082	>	0.041	0.045	≥	0.033
Dissolved total phosphorus	mg/ℓ	0.092	≥	0.084	0.114*	≥	0.099*
Total phosphorus*	mg/ℓ	0.235	>	0.155	0.234	>	0.181
Dissolved ammonium	mg/ℓ	0.47	=	0.47	0.47	=	0.46
Dissolved $NO_3 + NO_2$*	mg/ℓ	0.619	>	0.524	1.95	>	1.61
Dissolved total nitrogen	mg/ℓ	3.48*	>	1.76*	2.60	=	2.53
Total Kjeldahl nitrogen	mg/ℓ	5.25	≥	4.23	3.07	=	3.29
Fo/Fa ratio		1.71	=	1.75	1.44*	<	1.52*
Chlorophyll	μg/ℓ	10.24*	<	13.88*	1.09	≥	0.81
Phaeophytin*	μg/ℓ	4.36	<	5.23	1.67	>	0.78
Dissolved volatile organic C*	mg/ℓ	2.6	>	1.4	2.1	>	1.3
Dissolved total organic C	mg/ℓ	9.8	≥	8.8	9.2	=	9.1
Particulate organic carbon	mg/ℓ	--		--	2.79	≥	1.47
Dissolved calcium*	mg/ℓ	16.3	>	13.7	13.5	>	11.6
Dissolved iron*	mg/ℓ	0.489	>	0.269	0.281	=	0.299
Dissolved manganese*	mg/ℓ	0.184	>	0.046	0.061	>	0.029
Dissolved mercury	μg/ℓ	0.61	=	0.61	0.31	=	0.28
Dissolved zinc	mg/ℓ	0.088	≥	0.078	0.067*	≥	0.048*

Note: > indicates greater than; = indicates equal to; < indicates less than. Differences are not necessarily statistically significant.

* Parameter values were significantly different when comparing flood tide values and ebb tide values. Slack tidal values were not tested.

Table 53

Parameters That Tested Significantly Different by ANOVA Between the James River Artificial Habitat Development Site and a Reference Marsh. These Were Analyzed for Ebb and Flood Tides at Two Channels for Each Marsh During Four Tidal Cycles (Approximately 48 to 54 hrs) in August 1976 and Again in January 1977. Categories Were Very, Very Significant (VVS, $F_{0.001}$), Very Significant (VS, $F_{0.01}$) and Significant (S, $F_{0.05}$). Codes in Brackets List the Marsh (A=Artificial Habitat, R=Reference Marsh) Which Had the Higher Values for the Specific Parameter

MARSH FACTOR					
AUGUST 1976			JANUARY 1977		
VVS	VS	S	VVS	VS	S
(A) Suspended Solids	(R) Chlorophyll		(A) Water Temperature	(A) Alkalinity**	
(A) Turbidity*	(R) Phaeophytin*	(A) Conductivity*	(A) Conductivity*	(A) Phaeophytin*	
(R) Dissolved Oxygen*		(R) pH*,+	(A) Turbidity*		
(R) Oxygen Saturation*		(A) Volatile Dissolved Organic Carbon*+	(R) pH*		
(A) Dissolved Orthophosphate*		(A) Total Phosphorus*	(R) Dissolved Oxygen*		
(A) Total Dissolved Nitrogen			(R) Oxygen Saturation*		
(A) Nitrate + Nitrite*			(R) Fo/Fa Ratio		
(A) Dissolved Calcium*			(A) Volatile Dissolved Organic Carbon*		
(A) Dissolved Iron*			(A) Total Phosphorus*		
(A) Dissolved Manganese*			(A) Total Dissolved Phosphorus		
			(A) Dissolved Orthophosphate*		
			(A) Nitrate + Nitrite*		
			(A) Dissolved Calcium*		
			(R) Dissolved Iron*		
			(A) Dissolved Manganese*		
			(A) Dissolved Zinc		

* Parameter at some level of significance for both seasons

** Data excluded from the ANOVA for August 1976

+ Slightly less than $F_{0.05}$ (see Appendix E')

Table 54

Comparisons of Mean Water Quality Parameter Values for Separate Sampling Locations at the James River Artificial Habitat Development Site and the Reference Marsh During August 1976 (Summer) and January 1977 (Winter)

Parameter	Units	Summer						Winter					
		Development Site			Reference Marsh			Development Site			Reference Marsh		
		Pipe		Breach	Large		Small	Pipe		Breach	Large		Small
Conductivity	mmho/cm	0.178	>	0.171	0.164	=	0.167	0.170	<	0.192	0.104	=	0.109
Water temperature	°C	25.8	=	26.2	26.8	=	26.5	1.1	=	1.2	0.7	=	0.6
pH		7.11	<	7.28	7.34	=	7.30	7.41	=	7.39	8.00	=	7.99
Dissolved oxygen	mg/ℓ	5.48	<	6.00	7.10	>	6.77	11.40	=	11.50	12.25	=	12.34
Oxygen saturation	°/o	67	<	73	88	>	83	82	=	83	87	=	87
Alkalinity	meq/ℓ	--		--	--		--	0.49	=	0.49	0.39	=	0.40
Suspended solids	mg/ℓ	117	>	37	26	=	23	69	>	31	24	=	29
Turbidity	FTU	44	>	23	16	=	17	25	>	17	11	=	12
Dissolved orthophosphate	mg/ℓ	0.080	>	0.051	0.037	<	0.043	0.048	=	0.040	0.033	=	0.035
Dissolved total phosphorus	mg/ℓ	0.103	>	0.080	0.059	<	0.109	0.104	<	0.123	0.104	>	0.095
Total phosphorus	mg/ℓ	0.251	>	0.214	0.147	<	0.162	0.221	<	0.257	0.184	=	0.178
Dissolved ammonium	mg/ℓ	0.46	<	0.51	0.48	=	0.46	0.47	=	0.45	0.48	>	0.43
Dissolved $NO_3 + NO_2$	mg/ℓ	0.537	<	0.705	0.463	<	0.617	2.08	>	1.81	1.66	>	1.55
Dissolved total nitrogen	mg/ℓ	3.30	<	3.68	2.19	>	1.33	2.74	>	2.34	2.66	>	2.40
Total Kjeldahl nitrogen	mg/ℓ	5.83	>	4.45	4.70	>	3.76	3.69	>	2.86	3.54	>	3.30
Fo/Fa ratio		1.68	<	1.75	1.75	=	1.75	1.42	=	1.46	1.52	=	1.52
Chlorophyll	μg/ℓ	9.87	<	10.78	14.08	>	13.68	1.21	>	0.92	0.77	<	0.86
Phaeophytin	μg/ℓ	4.85	>	3.64	5.54	>	4.94	1.96	>	1.22	0.74	<	0.83
Dissolved volatile organic C	mg/ℓ	3.2	>	1.7	1.3	=	1.6	2.2	=	2.0	1.0	<	1.5
Dissolved total organic C	mg/ℓ	10.5	>	8.9	8.9	=	8.7	9.6	>	8.6	8.0	<	10.2
Particulate organic carbon	mg/ℓ	--		--	--		--	3.49	>	1.75	1.33	<	1.62
Dissolved calcium	mg/ℓ	17.0	>	15.2	14.1	>	13.2	13.4	=	13.6	11.5	=	11.9
Dissolved iron	mg/ℓ	0.625	>	0.296	0.276	=	0.261	0.288	=	0.271	0.289	<	0.309
Dissolved manganese	mg/ℓ	0.218	>	0.136	0.044	=	0.049	0.078	>	0.037	0.029	=	0.030
Dissolved mercury	μg/ℓ	0.64	>	0.55	0.55	=	0.66	0.28	=	0.39	0.28	=	0.26
Dissolved zinc	mg/ℓ	0.071	<	0.112	0.079	=	0.078	0.072	>	0.060	0.062	>	0.033

Note: > indicates greater than; = indicates equal to; < indicates less than. Differences are not necessarily statistically significant.

Table 55

Parameters That Tested Significantly Different by ANOVA at the James River Artificial Habitat Development Site and a Reference Marsh for Tides (Ebb or Flood), Stations (Two Tidal Channels at Each Marsh), Day or Night, Blocks (First Day or Second Day), and Replicates (Alpha or Beta). Categories Are Very, Very Significant (VVS, $F_{0.001}$), Very Significant (VS, $F_{0.01}$) and Significant (S, $F_{0.05}$). Codes in Brackets List Tides or Stations which Had Higher Values for the Specified Parameter

AUGUST 1976			JANUARY 1977		
VVS	VS	S	VVS	VS	SS
			TIDAL FACTOR		
(F) pH	(F) Dissolved Oxygen*	(F) Chlorophyll	(F) Water Temperature	(F) Phaeophytin	(F) Dissolved Oxygen*
(E) Dissolved Orthophosphate	(F) Oxygen Saturation*	(E) Volatile Dissolved Organic Carbon	(F) Oxygen Saturation*		(?) Dissolved Ammonium**
	(E) Dissolved Iron	(E) Dissolved Manganese*	(E) Dissolved Manganese*		
			STATION FACTOR		
	(P,S) Dissolved Total Phosphorus*	(P,L) Dissolved Calcium*	(B,?) Total Phosphorus	(P,L) Total Kjeldahl Nitrogen	(P,?) Turbidity (?)**
	(P,?) Dissolved Iron	(B,?) Dissolved Zinc*	(B,L) Dissolved Total Phosphorus*	(P,L) Dissolved Nitrate Plus Nitrite	(?,?) Dissolved Ammonium
			(P,L) Dissolved Total Nitrogen	(B,S) Dissolved Calcium*	(?,S) Dissolved Mercury
			(P,?) Dissolved Manganese		
			(P,L) Dissolved Zinc*		
			DAY/NIGHT FACTOR		
Water Temperature*	pH	Dissolved Oxygen	Water Temperature*	Total Kjeldahl Nitrogen	Turbidity
		Oxygen Saturation	Alkalinity^{+}		Dissolved Ammonium
		Fo/Fa Ratio	Total Phosphorus		
		Phaeophytin	Total Dissolved Phosphorus		
		Dissolved Manganese			
			BLOCKS (B) AND REPLICATES (R) FACTOR		
Water Temperature (B)	Dissolved Total Phosphorus (R)	Dissolved Mercury (B)		Dissolved Orthophosphate (R)	
				Dissolved Calcium (R)	
				Dissolved Zinc (R)	

Higher values listed as F = Flood, E = Ebb, P = Habitat Pipe, B = Habitat Breach, L = Reference Marsh Large Channel, S = Reference Marsh Small Channel, and ? = Uncertain

* Parameter at some level of significance for both seasons

** Slightly less than $F_{0.05}$ (see Appendix E')

$^{+}$ Data excluded from the ANOVA for August 1976

Table 56

Comparisons of Mean Water Quality Parameter Values for Ebb and Flood Tidal Periods at the James River Artificial Habitat Development Site Pipe During August 1976 (Summer) and January 1977 (Winter)

Parameter	Units	Summer Flood		Summer Ebb	Winter Flood		Winter Ebb
Conductivity*	mmho/cm	0.169	<	0.184	0.151	<	0.181
pH		7.29	>	7.00	7.47	=	7.38
Dissolved oxygen	mg/ℓ	6.24	>	4.87	11.48	=	11.27
Oxygen saturation	°/o	77	>	59	83	=	80
Alkalinity	meq/ℓ	--		--	0.48	=	0.51
Suspended solids	mg/ℓ	55	<	145	53	=	53
Turbidity	FTU	31	<	50	24	=	23
Dissolved orthophosphate	mg/ℓ	0.067	<	0.089	0.054	=	0.043
Dissolved total phosphorus	mg/ℓ	0.087	<	0.113	0.096	=	0.108
Total phosphorus*	mg/ℓ	0.176	<	0.277	0.204	≤	0.233
Dissolved ammonium*	mg/ℓ	0.43	≤	0.48	0.44	≤	0.50
Dissolved $NO_3 + NO_2$	mg/ℓ	0.674	>	0.435	2.03	=	2.11
Dissolved total nitrogen*	mg/ℓ	2.83	<	3.61	2.60	≤	2.83
Total Kjeldahl nitrogen	mg/ℓ	6.01	≥	5.74	3.40	≤	3.88
Fo/Fa ratio		1.69	=	1.67	1.44	=	1.40
Chlorophyll	μg/ℓ	10.25	≥	9.62	1.11	=	1.01
Phaeophytin*	μg/ℓ	4.09	<	5.22	1.62	<	2.62
Dissolved volatile organic C*	mg/ℓ	2.4	<	3.8	1.8	<	2.7
Dissolved total organic C	mg/ℓ	9.4	<	11.1	9.5	=	9.5
Particulate organic carbon	mg/ℓ	--		--	2.78	=	2.70
Dissolved calcium	mg/ℓ	15.5	<	17.9	13.8	=	13.2
Dissolved iron*	mg/ℓ	0.776	≤	0.795	0.255	<	0.332
Dissolved manganese*	mg/ℓ	0.127	<	0.273	0.045	<	0.113
Dissolved mercury	μg/ℓ	0.74	≥	0.58	0.26	=	0.31
Dissolved zinc	mg/ℓ	0.067	=	0.074	0.074	=	0.070

Note: > indicates greater than; = indicates equal to; < indicates less than. Differences are not necessarily statistically significant.

* Ebb tidal cycle (porewater drainage + low slack + ebb) statistical mean greater than flood cycle (flood + high slack) statistical mean concentrations for both August and January sampling periods.

Table 57

Cation Exchange Capacity (NaEC) of Suspended Sediments Collected at the Tidal Channels of the James River Artificial Habitat Development Site and a Reference Marsh, August 1976 and January 1977

August 1976			January 1977		
Location	Tide	CEC (meq/100 g)	Location	Tide	CEC (meq/100 g)
Habitat Site			Habitat Site		
Habitat Pipe and	Ebb	39	Pipe	Ebb	114
Breach Combined	Ebb	63	Pipe	Flood	164
			Breach	Ebb	97
			Breach	Flood	116
Mean ± Std. Dev.		51 ± 17			123 ± 29
Reference Marsh					
Reference Large			Reference Marsh		
and Small Channels	Ebb	284	Large Channel	Ebb	151
Combined	Flood	96	Large Channel	Flood	129
			Small Channel	Ebb	141
			Small Channel	Flood	106
Mean ± Std. Dev.		190 ± 133			132 ± 19

Table 58

Net Chemical Exports Through All Sampling Locations at the James River Artificial Habitat Development Site and Reference Marsh During August 1976 (Summer) and January 1977 (Winter)

Development Site Parameter	Export, kg	Reference Marsh Parameter	Export, kg
August 1976			
Dissolved volatile organic carbon	61.2 ± 15.2*	Total Kjeldahl nitrogen	292 ± 120*
Dissolved orthophosphate	0.56 ± 0.15*	Dissolved zinc	3.93 ± 1.67*
Particulate copper	0.124 ± 0.015*	Dissolved manganese	3.47 ± 0.91*
Dissolved orthophospate (serial at AB)	0.10 ± 0.09*	Dissolved orthophosphate	1.60 ± 0.68*
		Dissolved orthophosphate†	0.38 ± 0.30*
		Particulate nickel	0.743 ± 0.097*
		Particulate copper	0.336 ± 0.056*
		Dissolved mercury	0.035 ± 0.017*
Dissolved total nitrogen	34.63 ± 8.68**	Dissolved volatile organic carbon	142 ± 104**
Dissolved manganese	0.99 ± 0.67**	Dissolved nitrate plus nitrite‡	17.2 ± 10.7**
Dissolved total phosphorus	0.30 ± 0.16**	Dissolved iron	7.84 ± 4.86**
		Dissolved total phosphorus	1.89 ± 1.37**
		Particulate lead	0.425 ± 0.086**
		Particulate cadmium	0.030 ± 0.010**
Particulate iron	13.76 ± 17.54††	Dissolved total organic carbon	276 ± 389††
Dissolved nitrate plus nitrite‡	1.21 ± 1.83††	Dissolved oxygen	70 ± 109††
January 1977			
Dissolved total organic carbon	60.5 ± 44.5*	None for first category*	
Dissolved volatile organic carbon	23.7 ± 9.9*		
Alkalinity‡‡	3.91 ± 2.71		
Particulate cadmium§	0.0009 ± 0.0003*		
Dissolved mercury	0.0025 ± 0.0081**	Dissolved total organic carbon	514 ± 211**
		Particulate cadmium	0.007 ± 0.004**
Dissolved manganese	0.24 ± 0.31 ††	Total Kjeldahl nitrogen	29.2 ± 108††
Dissolved total phosphorus	0.23 ± 0.25 ††	Dissolved orthophosphate	0.33 ± 0.55††

Note: Net export values are volume normalized to allow direct ebb to flood comparisons.
* Volume normalized net mass transport at both channels were greater than the error terms, expressed at the ± one sigma level.
** Volume normalized net mass transport at one channel only was greater than the error terms, expressed at the ± one sigma level.
† Analysis of serial data for small reference channel only; the large reference channel was not considered in calculations of total net mass transport because serial data for the large reference channel was not available.
†† Error terms at the ± one sigma level were greater than the volume normalized net mass transport at both channels.
‡ Composite data for the experimental pipe at large reference channel plus serial data for the experimental breach or small reference channel.
‡‡ Data for winter period only were available; values are in equivalents rather than kg as with the other parameters.
§ Significant net export calculated for the breach only. Data for the pipe were below detection limit.

Table 59

Net Chemical Imports Through All Sampling Locations at the James River Artificial Habitat Development Site and Reference Marsh During August 1976 (Summer) and January 1977 (Winter)

Development Site		Reference Marsh	
Parameters	Import, kg	Parameters	Import, kg
August 1976			
Dissolved oxygen	55 ± 8.3*	Dissolved total nitrogen	71.7 ± 80.6**
		Dissolved ammonium†	13.2 ± 12.1**
		Particulate zinc	0.49 ± 0.18**
Particulate manganese	0.73 ± 0.45**	Dissolved ammonium†	11.0 ± 13.2†
Total phosphorus	0.59 ± 0.85**	Total phosphorus	2.56 ± 2.48†
Dissolved zinc	0.41 ± 0.28**	Chlorophyll	0.73 ± 252†
Dissolved ammonium	0.34 ± 1.45†		
Chlorophyll	0.09 ± 23.6†		
January 1977			
Particulate manganese	0.601 ± 0.150*	Dissolved volatile organic carbon	87 ± 24*
		Particulate manganese	3.25 ± 0.66*
Suspended solids	175 ± 213**	Dissolved calcium	148 ± 92**
Dissolved total nitrogen	9.56 ± 5.92**	Particulate iron	82 ± 31**
Dissolved orthophosphate	0.14 ± 0.13**	Particulate calcium	9.05 ± 2.62**
		Alkalinity††	6.69 ± 7.47**
		Particulate lead	0.157 ± 0.068**
		Particulate copper‡	0.045 ± 0.014**
Particulate carbon††	8.43 ± 13.47†	Dissolved oxygen	77 ± 79†
		Chlorophyll	0.02 ± 13†
		Phaeophytin	0.04 ± 19†
Dissolved zinc	0.085 ± 0.311†		
Phaeophytin	0.006 ± 8.35†		

Note: Net import values are volume normalized to allow direct flood to ebb comparisons.

* Volume normalized net mass transport at both channels was greater than the error terms, expressed at the ± one sigma level.

** Volume normalized net mass transport at both channels was greater than the error terms, expressed at the ± one sigma level. Dissolved ammonium concentrations after H_2SO_4 storage.

† Error terms at the ± one sigma level were greater than the volume normalized net mass transport of both channels. Dissolved ammonium concentrations after $HClO_4$ storage.

†† Alkalinity and particulate carbon data were available only for the winter sampling period; values for alkalinity are in equivalents rather than kg as with the other parameters.

‡ Significant net import calculated for the large reference channel only. Data not available for the small reference channel.

Table 60

Parameters Calculated as Net Exports at one Sampling Location and Net Imports at the Other Sampling Location in both the James River Artificial Habitat Development Site and Reference Marsh during August 1976 (Summer) and January 1977 (Winter)

Development Site					Reference Marsh				
Parameters**	Location	Export, kg	Location	Import, kg	Parameters**	Tidal Channel	Export, kg	Tidal Channel	Import, kg
August 1976									
Suspended solids	Breach	119 ± 133	Pipe	190 ± 294	Suspended solids	Small	198 ± 282	Large	56 ± 692
Dissolved total organic carbon	Pipe	55.6 ± 22.9*	Breach	0.33 ± 67.7	Dissolved calcium	Large	116 ± 98*	Small	14.5 ± 48.2
Dissolved calcium	Pipe	16.3 ± 9.0*	Breach	2.98 ± 13.5	Particulate iron	Small	27.8 ± 11.7*	Large	3.5 ± 32
Total Kjeldahl nitrogen	Breach	4.44 ± 20.8	Pipe	20.7 ± 19.3*	Dissolved nitrate plus nitrite†	Large	10.1 ± 7.4*	Small	0.36 ± 4.35
Dissolved iron*	Breach	2.64 ± 0.84*	Pipe	2.41 ± 1.29*	Particulate calcium	Small	1.52 ± 1.05*	Large	0.44 ± 3.20
Dissolved nitrate plus nitrite	Pipe	0.88 ± 0.89	Breach	0.33 ± 1.61	Particulate manganese	Small	0.45 ± 0.57	Large	0.98 ± 1.68
Dissolved ammonium††	Breach	0.73 ± 1.03	Pipe	0.14 ± 0.53	Phaeophytin	Small	0.06 ± 67	Large	0.27 ± 107
Particulate calcium	Pipe	0.39 ± 0.92	Breach	0.09 ± 0.68					
Particulate nickel*	Pipe	0.035 ± 0.018*	Breach	0.030 ± 0.014*					
Particulate lead	Pipe	0.016 ± 0.023	Breach	0.006 ± 0.012					
Particulate zinc	Pipe	0.015 ± 0.074	Breach	0.061 ± 0.050*					
Phaeophytin	Pipe	0.003 ± 5.96	Breach	0.02 ± 10.1					
Particulate cadmium*	Pipe	0.0018 ± 0.0016*	Breach	0.0108 ± 0.0025*					
Dissolved mercury	Breach	0.0008 ± 0.0019	Pipe	0.0041 ± 0.0006*					
January 1977									
Dissolved oxygen	Breach	9.3 ± 18.3	Pipe	10.5 ± 5.8*	Dissolved total nitrogen*	Large	131 ± 48*	Small	16.4 ± 15.3*
Particulate iron	Breach	2.63 ± 4.99	Pipe	17.4 ± 4.5*	Suspended solids	Small	72 ± 719	Large	231 ± 646
Dissolved ammonium	Pipe	1.54 ± 1.18*	Breach	0.59 ± 1.06	Dissolved ammonium*	Large	33 ± 12*	Small	14 ± 4.7*
Dissolved calcium	Pipe	1.39 ± 8.11	Breach	10.5 ± 22.1	Particulate carbon‡	Small	7.75 ± 39.98	Large	13.73 ± 33.68
Total Kjeldahl nitrogen	Pipe	1.28 ± 6.14	Breach	16.7 ± 10.3*	Dissolved nitrate plus nitrite	Large	7.50 ± 32.9	Small	5.49 ± 10.6
Dissolved nitrate plus nitrite	Pipe	1.22 ± 3.54	Breach	2.59 ± 5.78	Dissolved iron	Small	0.90 ± 2.40	Large	2.47 ± 4.18
Dissolved iron	Breach	0.96 ± 1.87	Pipe	0.10 ± 0.54	Dissolved total phosphorus	Small	0.82 ± 0.63*	Large	0.16 ± 0.97
Particulate calcium	Breach	0.38 ± 0.52	Pipe	1.86 ± 0.47*	Total phosphorus	Small	0.72 ± 1.29	Large	1.78 ± 2.94
Total phosphorus	Pipe	0.34 ± 0.22*	Breach	0.32 ± 0.48	Dissolved zinc*	Small	0.68 ± 0.37*	Large	1.32 ± 0.98*
Particulate nickel*	Breach	0.020 ± 0.009*	Pipe	0.023 ± 0.007*	Particulate zinc*	Small	0.429 ± 0.176*	Large	0.448 ± 0.130*
Particulate zinc	Breach	0.019 ± 0.032	Pipe	0.153 ± 0.034*	Dissolved manganese	Small	0.30 ± 0.16*	Large	0.09 ± 0.34
Particulate copper*	Breach	0.017 ± 0.006*	Pipe	0.044 ± 0.008*	Particulate nickel*	Small	0.196 ± 0.081*	Large	0.074 ± 0.048*
Particulate lead	Breach	0.007 ± 0.104	Pipe	0.030 ± 0.009*	Dissolved mercury	Large	0.001 ± 0.003	Small	0.006 ± 0.004*
Chlorophyll	Pipe	0.001 ± 2.14	Breach	0.001 ± 3.95					

Note: Net imports and export values normalized to allow direct flood to ebb comparisons.
* Error terms listed at the ± one sigma level. Parameter listing indicates significant volume normalized export and import terms, which are denoted in their respective columns.
** Ranked according to decreasing net export.
† Transport calculated for composited samples only; see Table 58 for other calculations.
†† Storage for six weeks (-20 C) with perchloric acid.
‡ Particulate carbon data were available only for the winter sampling period.

Table 61

Net Transport of Dissolved and Particulate Metals at the James River Artificial Habitat Development Site and Reference Marsh

	Development Site				Reference Marsh			
	Export, kg		Import, kg		Export, kg		Import, kg	
Parameter	Particulate	Dissolved	Particulate	Dissolved	Particulate	Dissolved	Particulate	Dissolved
				August 1976				
Cadmium		--	0.009	--	0.030	--		--
Calcium	0.30	13.3*			1.08	102*		
Copper	0.124	--		--	0.336	--		--
Iron	13.76*	0.23			24.3*	7.84		
Lead	0.010	--		--	0.425	--		--
Manganese		0.99	0.73			3.47*	0.53	
Mercury	--		--	0.003	--	0.035	--	
Nickel	0.005	--		--	0.743	--		--
Zinc			0.046	0.41*		3.93*	0.49	
				January 1977				
Cadium	0.0009	--		--	0.007	--		--
Calcium			1.48	9.11*			9.05	148*
Copper		--	0.027	--		--	0.045	--
Iron		0.86	14.8*				82*	1.57
Lead		--	0.023	--		--	0.16	--
Manganese		0.24	0.60			0.21	3.25*	
Mercury	--	0.0025	--		--		--	0.005
Nickel		--	0.003	--	0.122	--		--
Zinc			0.134	0.085			0.019	0.64*

Note: 1. Net import and export values are volume normalized to allow direct flood to ebb comparisons.
2. See Tables 58-60 for standard error values for all listed mean values.
3. -- Indicates that no transport was calculated due mostly to sample levels below analytical detection limits (Table 5 in Volume I).

* Denotes phase for calcium, iron, manganese, and zinc which has greater net mass transport.

Table 62

Net Mass Transport of Suspended Solids, Dissolved Oxygen, Nutrients, Carbon, Chlorophyll, and Phaeophytin at the James River Site and a Reference Marsh

Parameter	Development Site		Reference Marsh	
	Export, kg	Import, kg	Export, kg	Import, kg
August 1976				
Suspended solids		71	142	
Dissolved oxygen		55	70	
Dissolved orthophosphate	0.56		1.60	
Dissolved total phosphorus	0.30		1.89	
Total phosphorus		0.59		2.56
Dissolved ammonium		0.34		13.2
Dissolved nitrate plus nitrite	0.55		17.2	
Dissolved total nitrogen	34.6			71.7
Total Kjeldahl nitrogen		16.3	292	
Dissolved total organic carbon	55.3		276	
Dissolved volatile organic carbon	61.2		142	
Chlorophyll		0.09		0.73
Phaeophytin		0.02		0.21
January 1977				
Suspended solids		175		159
Dissolved oxygen		1.2		77
Dissolved orthophosphate		0.14	0.33	
Dissolved total phosphorus	0.23		0.66	
Total phosphorus	0.02			1.06
Dissolved ammonium	0.95		19	
Dissolved nitrate plus nitrite		1.37	2.0	
Dissolved total nitrogen		9.56	115	
Total Kjeldahl nitrogen		15.4	29.2	
Dissolved total organic carbon	60.5		514	
Dissolved volatile organic carbon	23.7			87
Particulate organic carbon*		8.43		5.98
Chlorophyll	0.00			0.02
Phaeophytin		0.006		0.04

Note: 1. Net import and export values are volume normalized to allow direct flood to ebb comparisons.
2. See Tables 58-60 for standard error values for all listed mean values.
* Calculated for winter sampling period only.

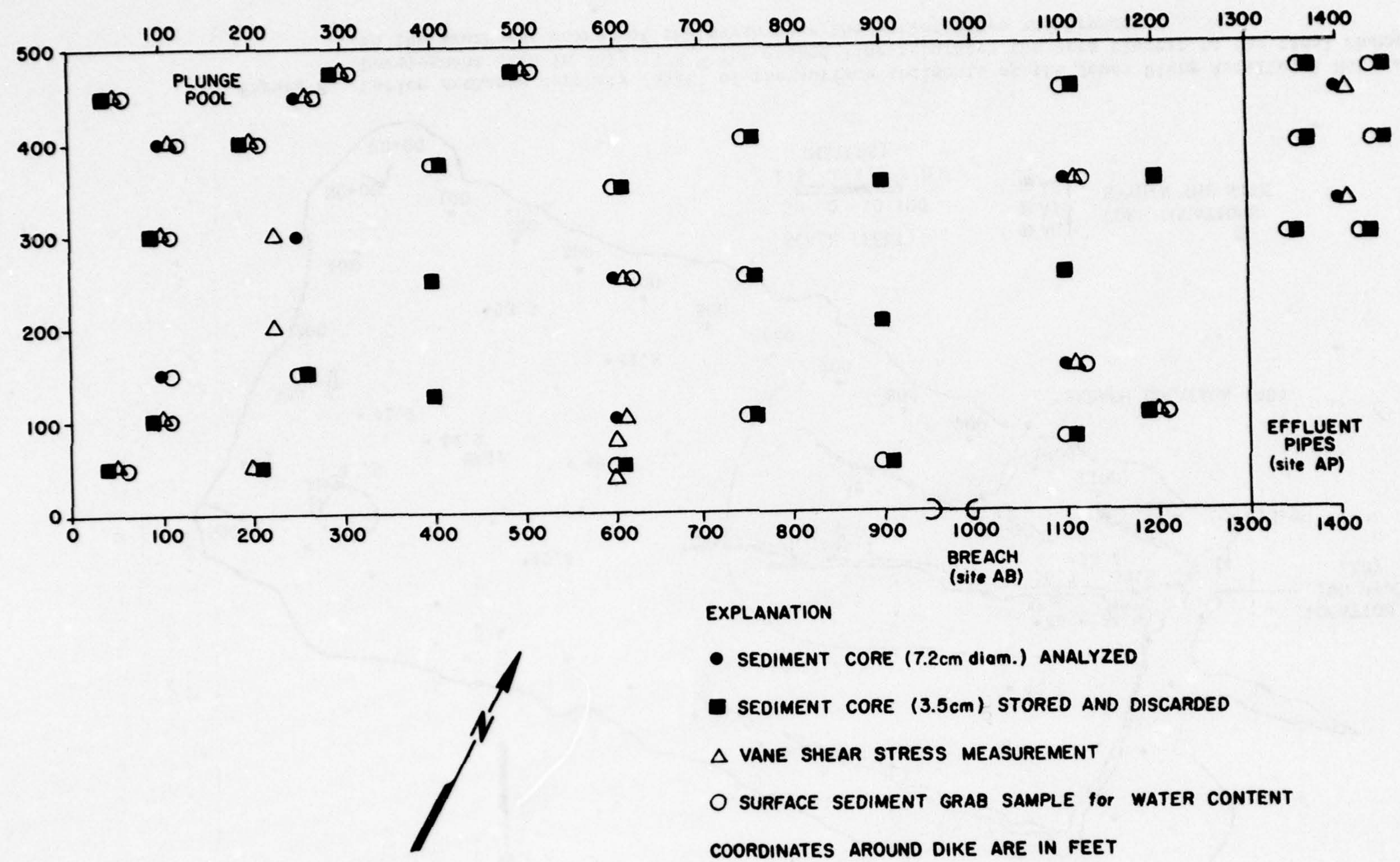


Figure 7. Locations of sampling sites at the James River Artificial Habitat Development Site in July 1975.

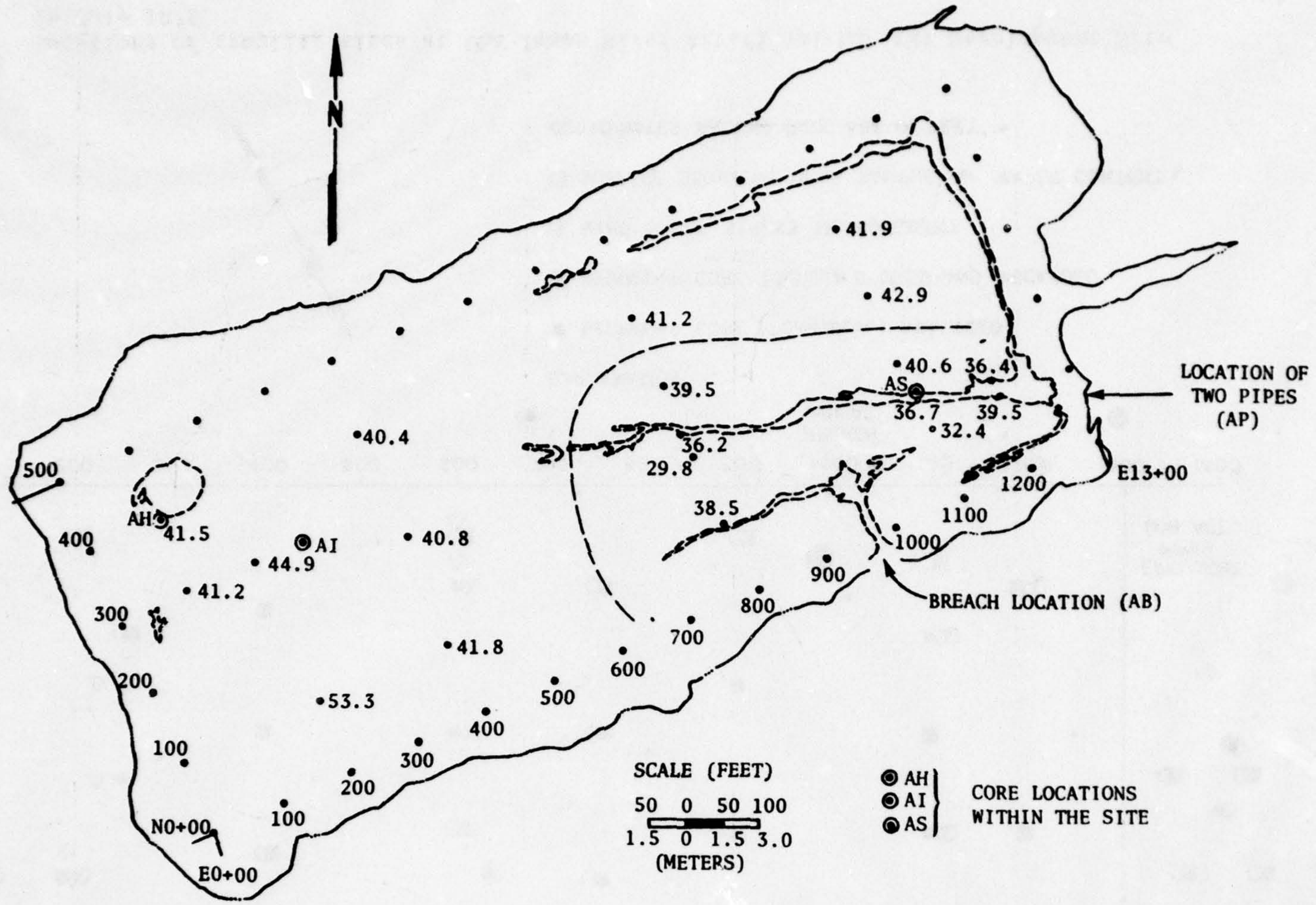


Figure 8. Cation exchange capacity (NaEC) of the surface sediments at the James River Artificial Habitat Development Site in July 1976. The dashed line separates the area closest to the tidal channel in the southeast corner of the marsh near the outlet pipes and breach.

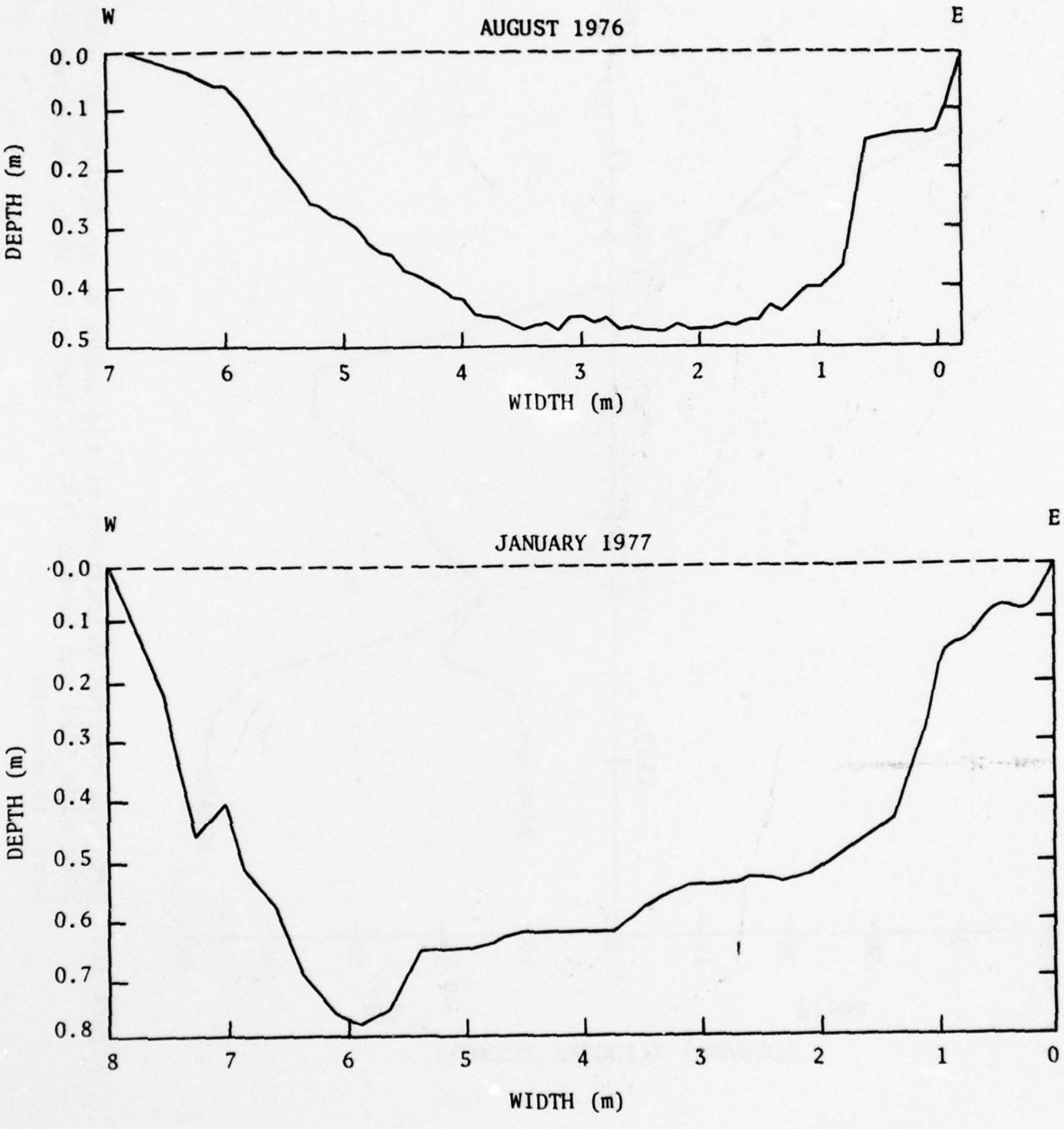


Figure 9. Cross sections of the breach (AB) at the James River Artificial Habitat Development Site, Virginia, during August 1976 and January 1977.

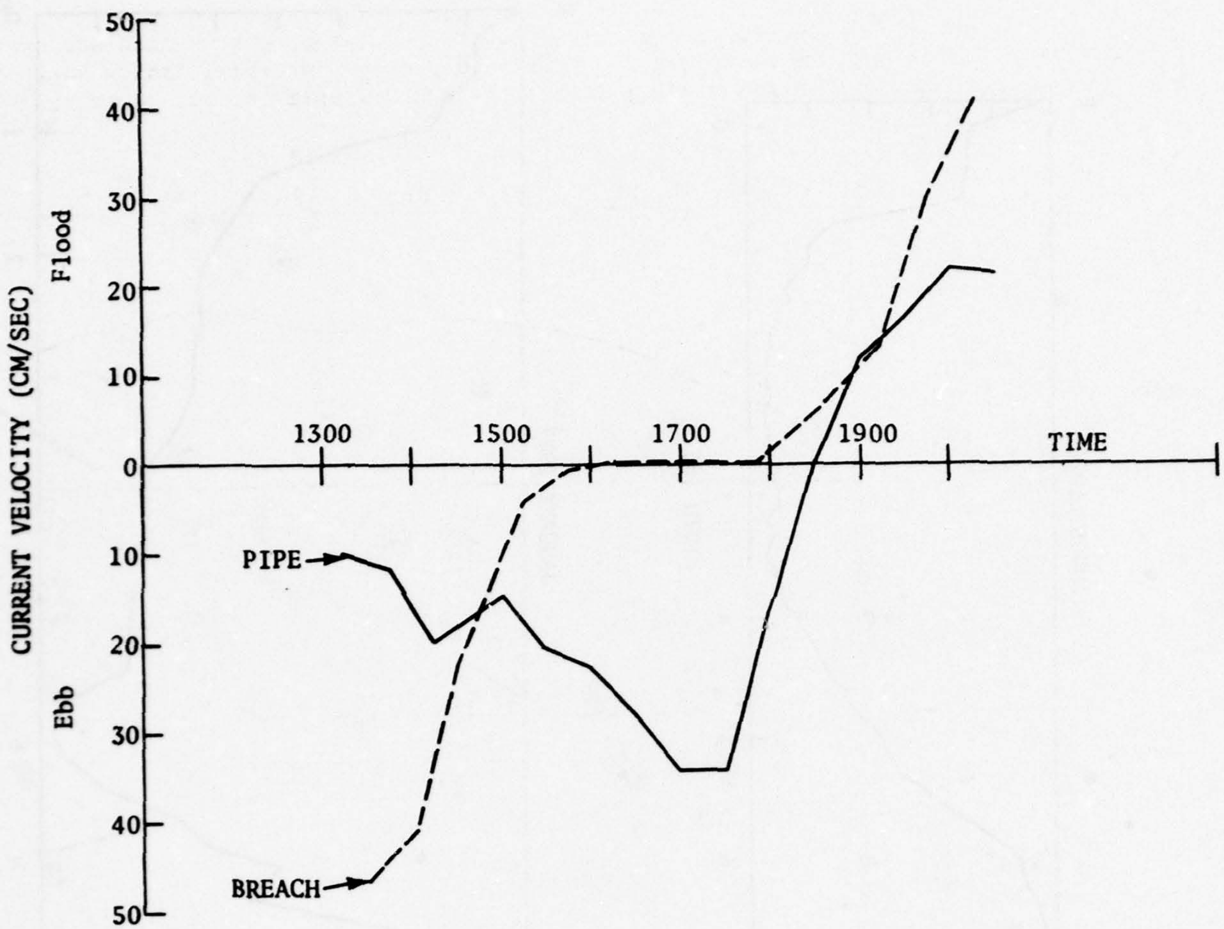
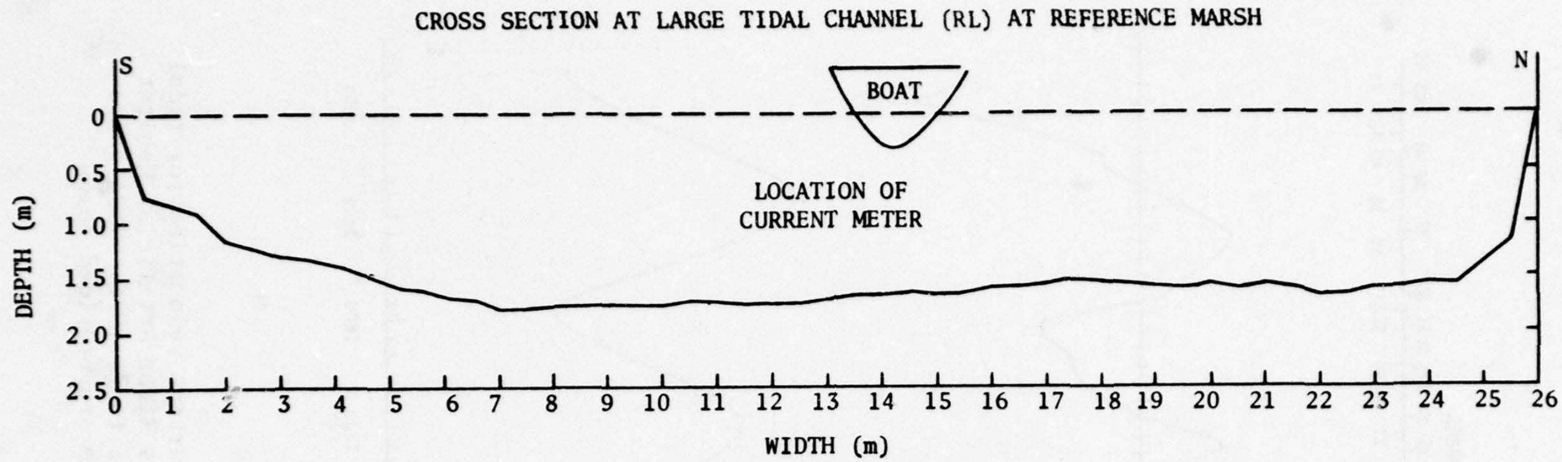


Figure 10. Detailed current velocities at the James River Artificial Habitat Development Site pipe (AP) and breach (AB) on August 6, 1976. Measurements were made every 15 minutes.



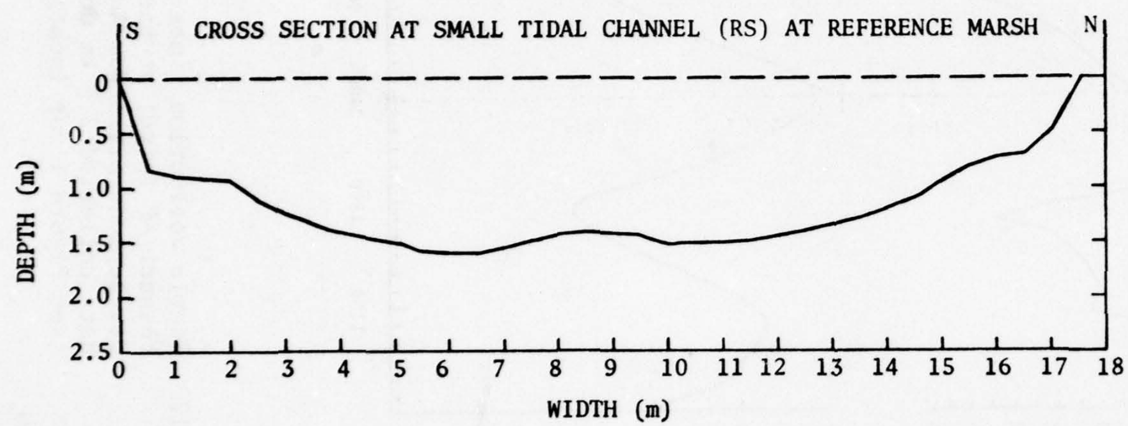


Figure 11. Cross sections of the two tidal channels at the reference marsh (see Figure 3) near Ducking Stool Point, James River, Virginia. Zero depth was low slack water at 1100 hours on August 7, 1976, which was the same as 1.0 foot tidal height at the WES tide gauge.

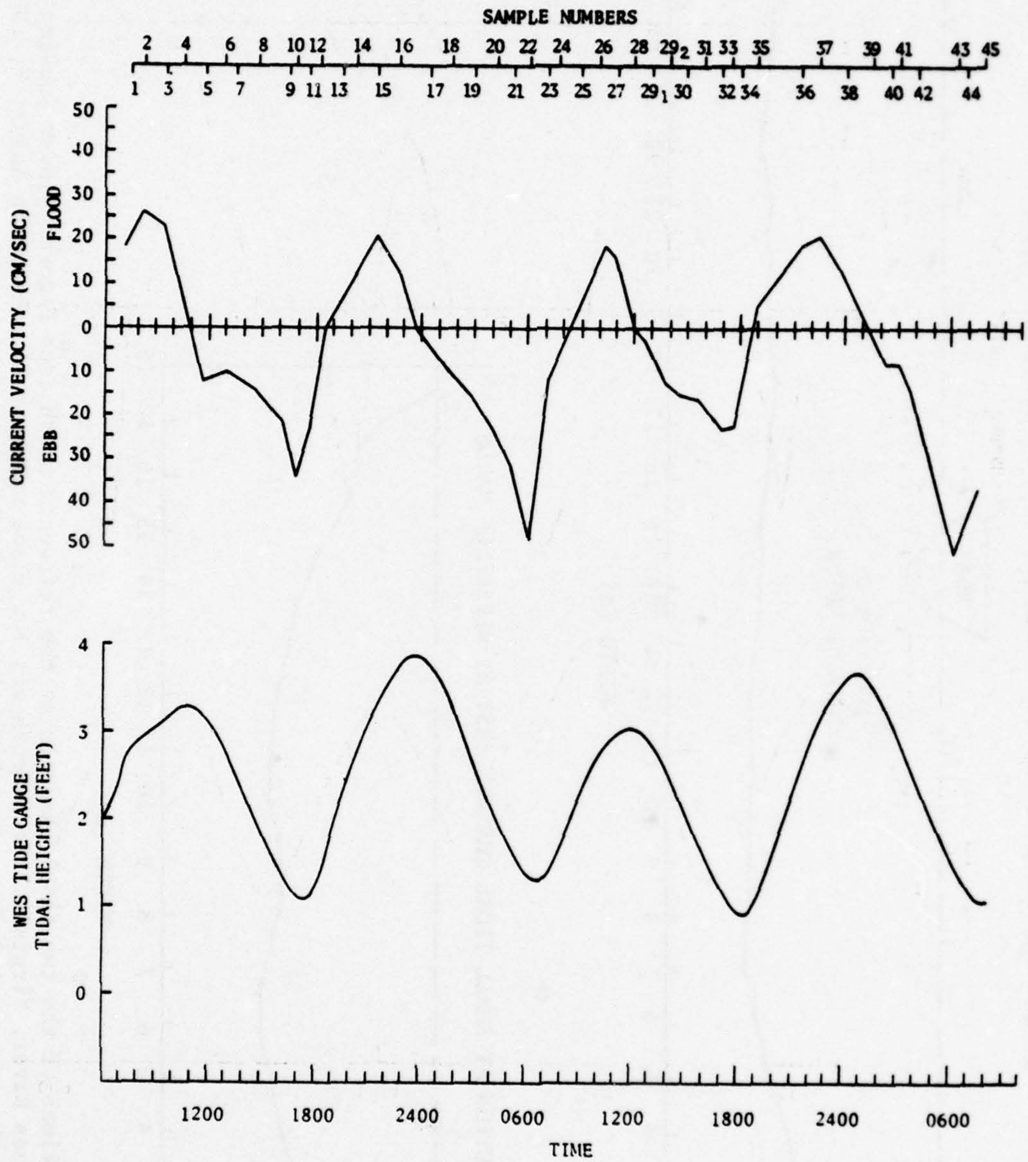


Figure 12. Sample collection times and current velocities for tidal channel AP (pipe) at the James River Artificial Habitat Development Site from August 5 to 7, 1976. Tide gauge data collected 2.7 km upstream are provided below (see Figure 1 for locations).

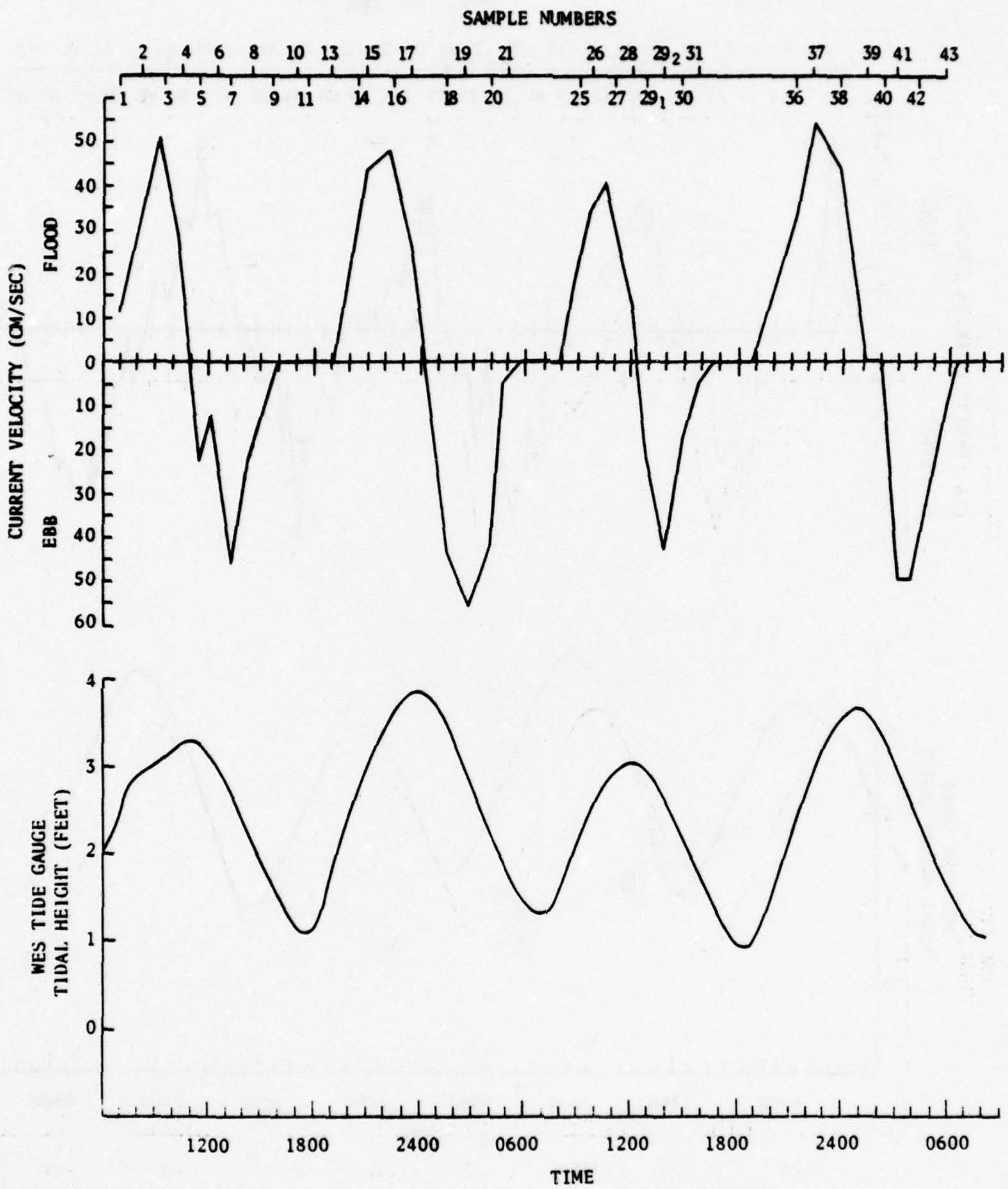


Figure 13. Sample collection times and current velocities for tidal channel AB (breach) at the James River Artificial Habitat Development Site from August 5 to 7, 1976. Tide gauge data collected 2.7 km upstream are provided below (see Figure 1 for locations).

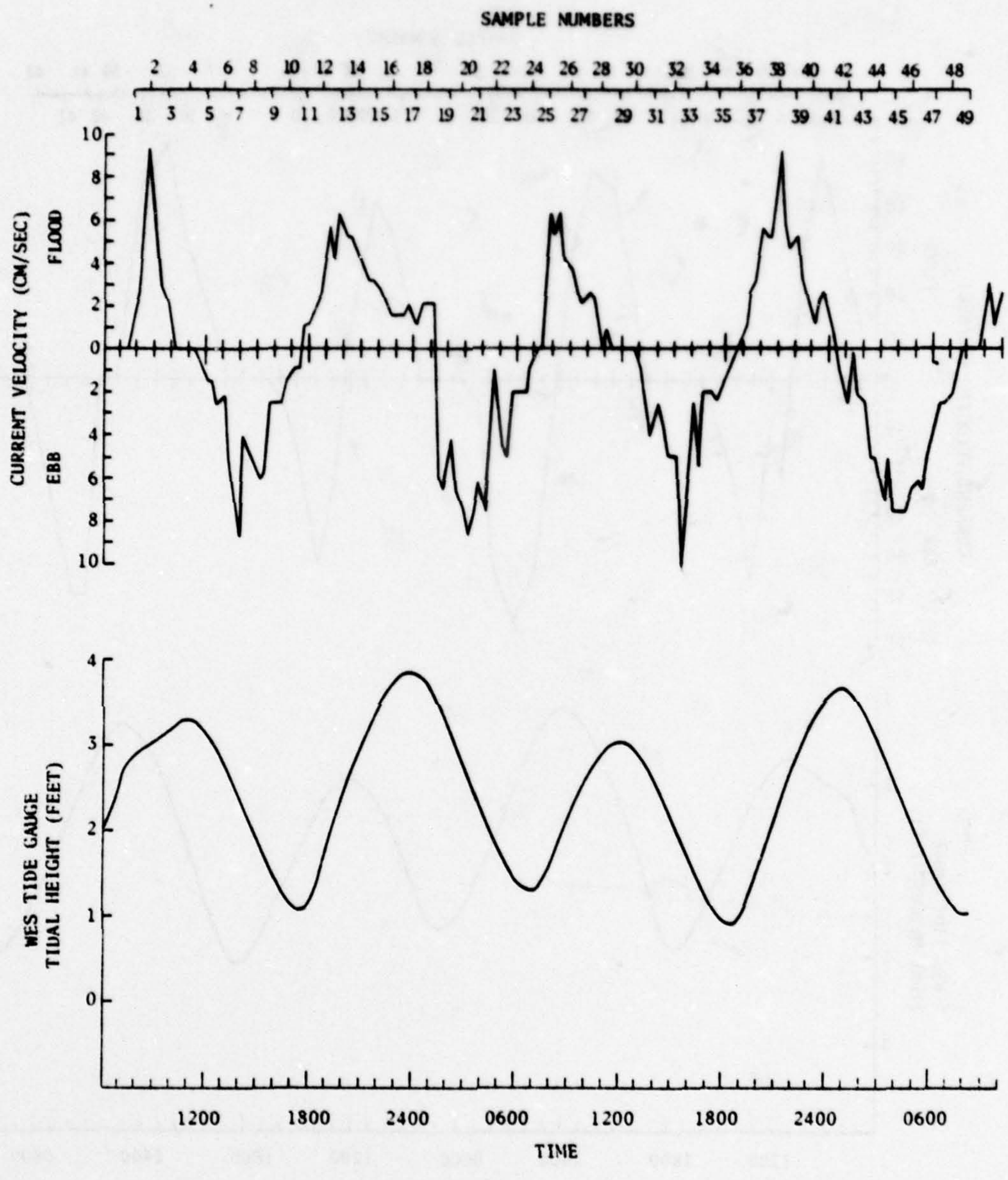


Figure 14. Sample collection times and current velocities for tidal channel RL at the reference marsh, James River, from August 5 to 7, 1976. Tide gauge data are provided below (see Figure 1). Samples from channel RS were collected at the same time as RL above, except numbers 35 and 36 were not taken and number 34 was collected at 1730 hours on August 6.

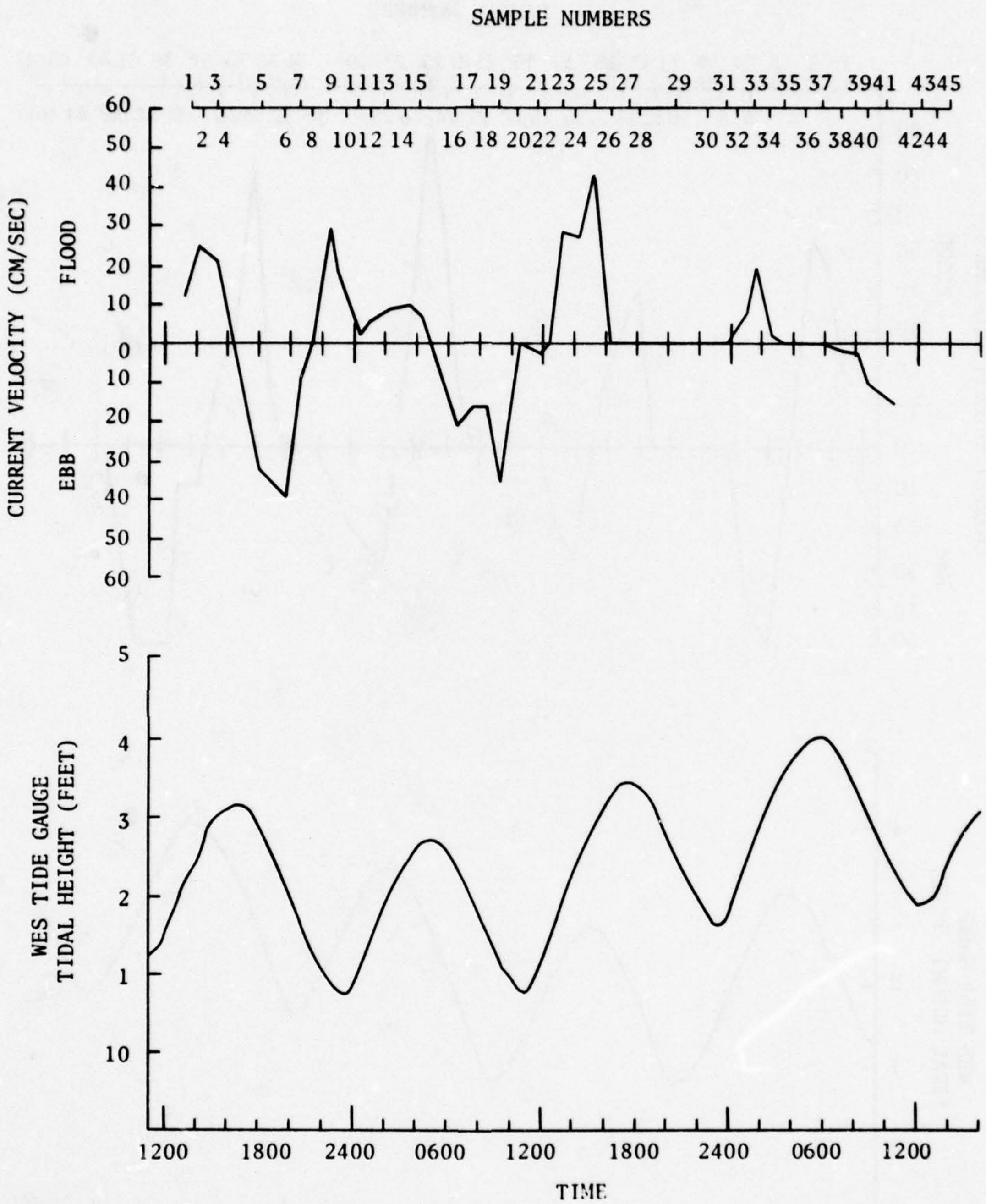


Figure 15. Sample collection times and current velocities for tidal channel AP (pipe) at the James River Artificial Habitat Development Site from January 8 to 10, 1977. Tide gauge data collected 2.7 km upstream are provided below (see Figure 1 for locations).

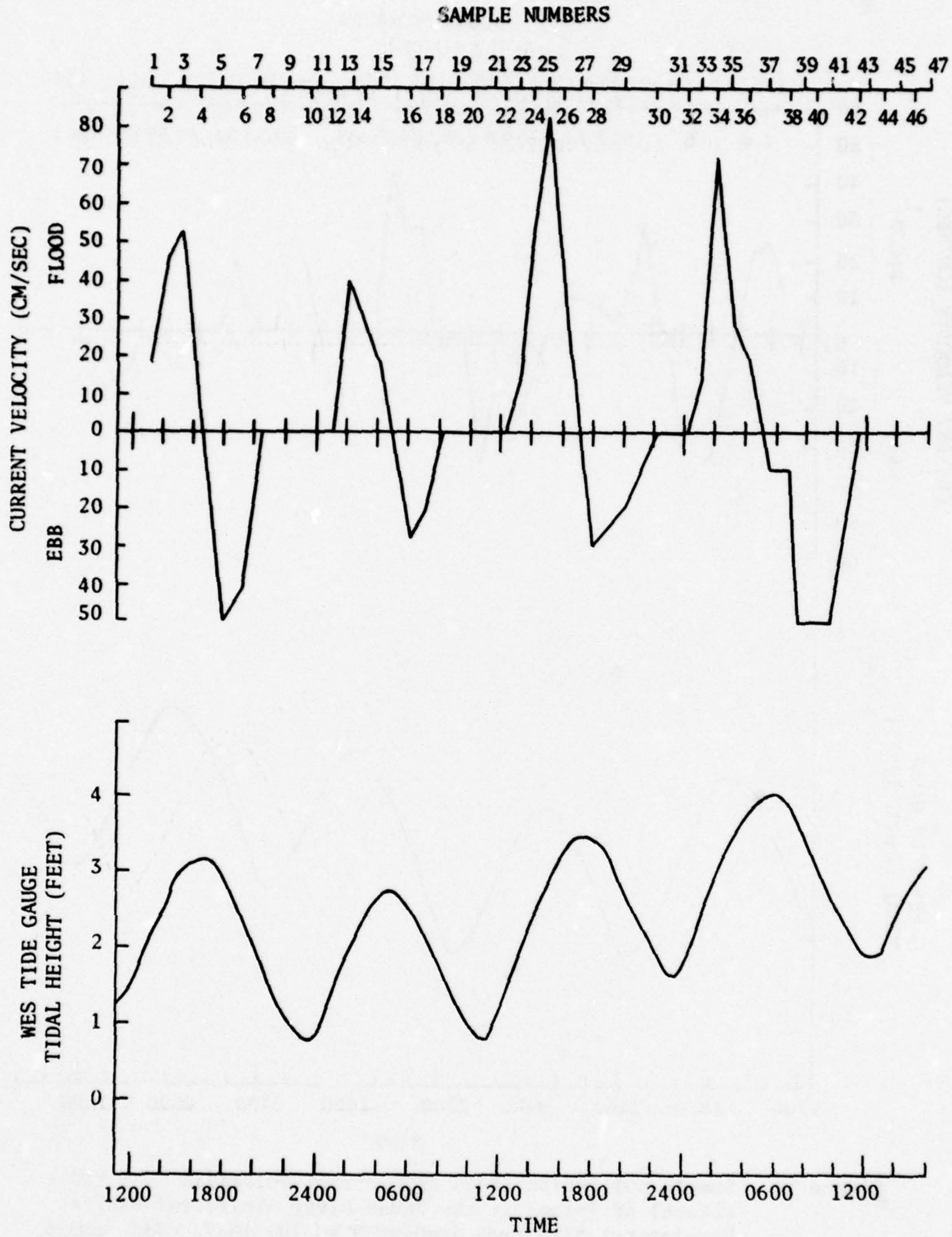


Figure 16. Sample collection times and current velocities for tidal channel AB (breach) at the James River Artificial Habitat Development Site from January 8 to 10, 1977. Tide gauge data collected 2.7 km upstream are provided below (see Figure 1 for locations).

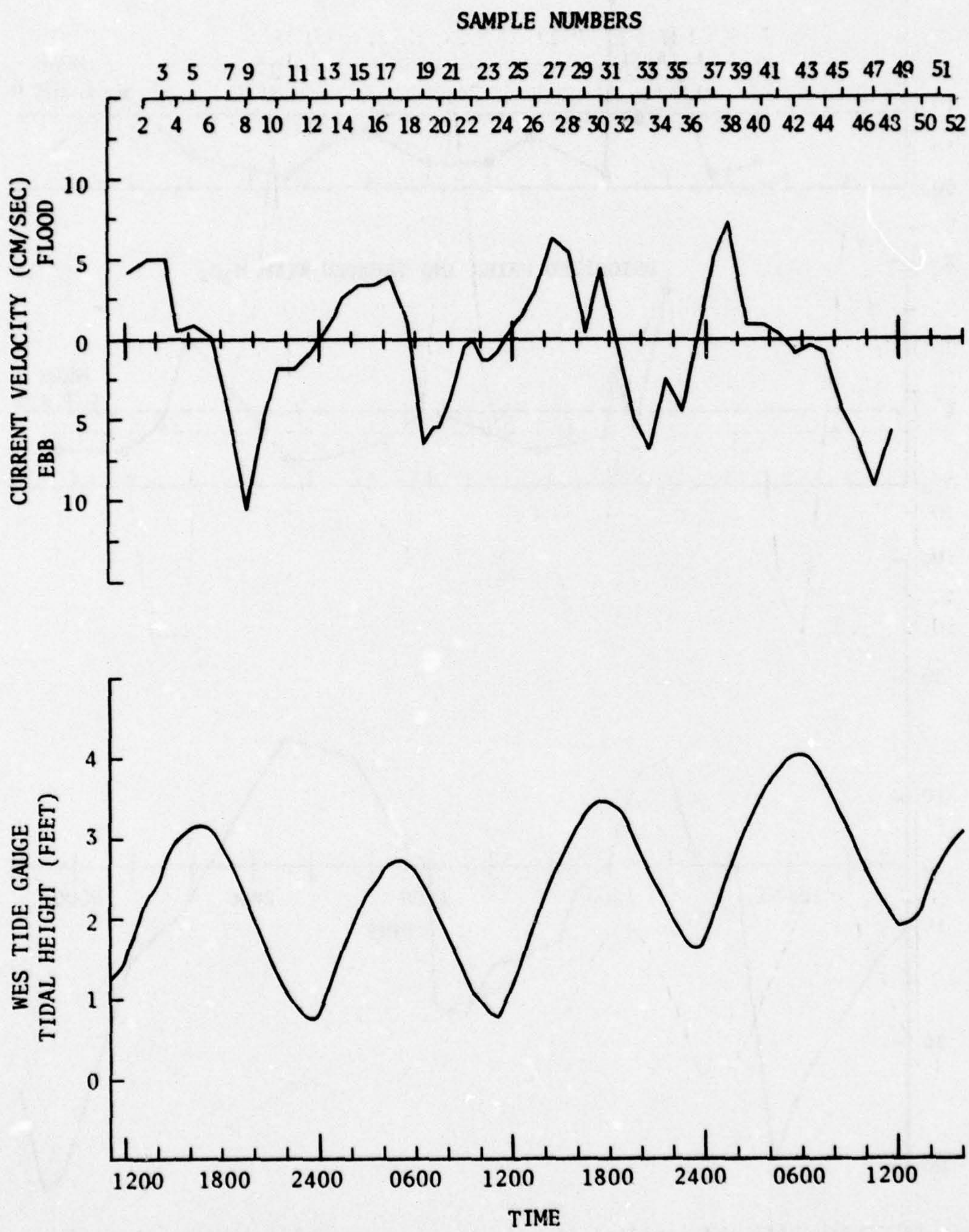


Figure 17. Sample collection times and current velocities for tidal channel RL at the reference marsh, James River, from January 8 to 10, 1977. Tide gauge data are provided below. Samples from channel RS were collected within 15-30 minutes of the time at RL shown above (see Figure 1 for locations).

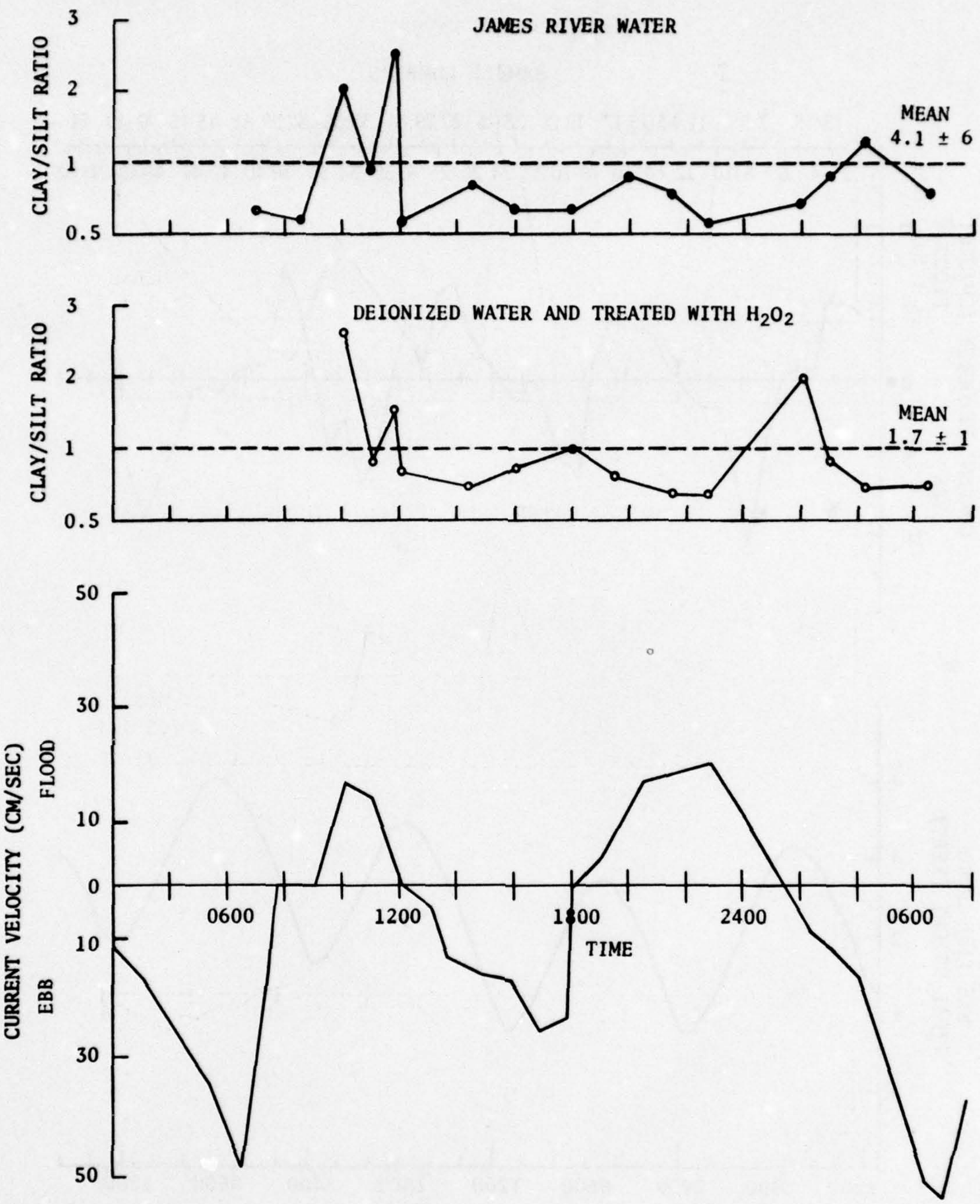


Figure 18. Naturally and artificially dispersed suspended sediments plotted as clay/silt ratios in order to emphasize the periods when the weight percent of clay (<2μ) was greater than the percent silt. Data are for August 6 and 7, 1976 at site AP (pipe), James River Artificial Habitat Development Site.

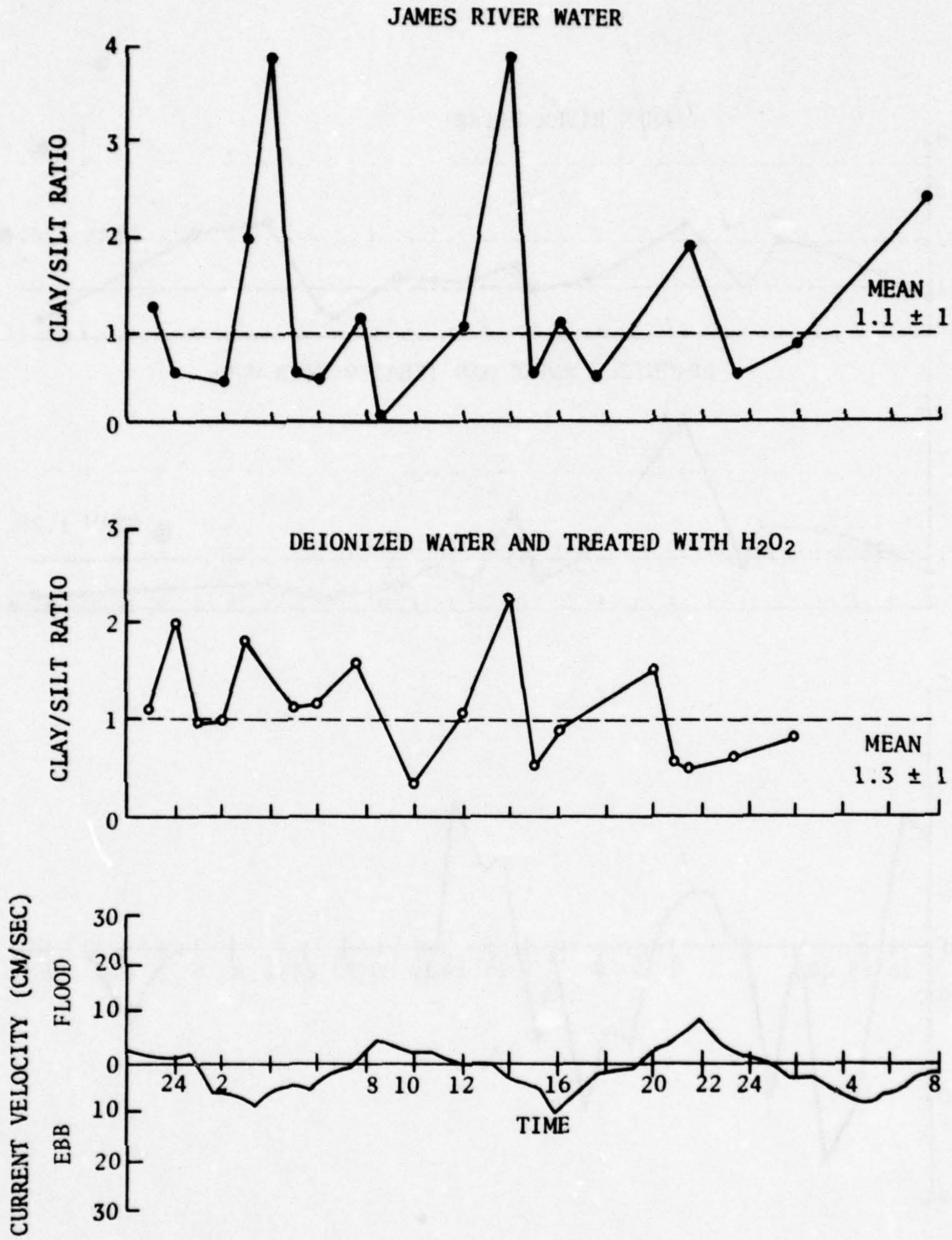


Figure 19. Naturally and artificially dispersed suspended sediments plotted as clay/silt ratios in order to emphasize the periods when the weight percent of clay (<2μ) was greater than the percent silt. Data are for August 6 and 7, 1976, at channel RS of the reference marsh, James River, Virginia.

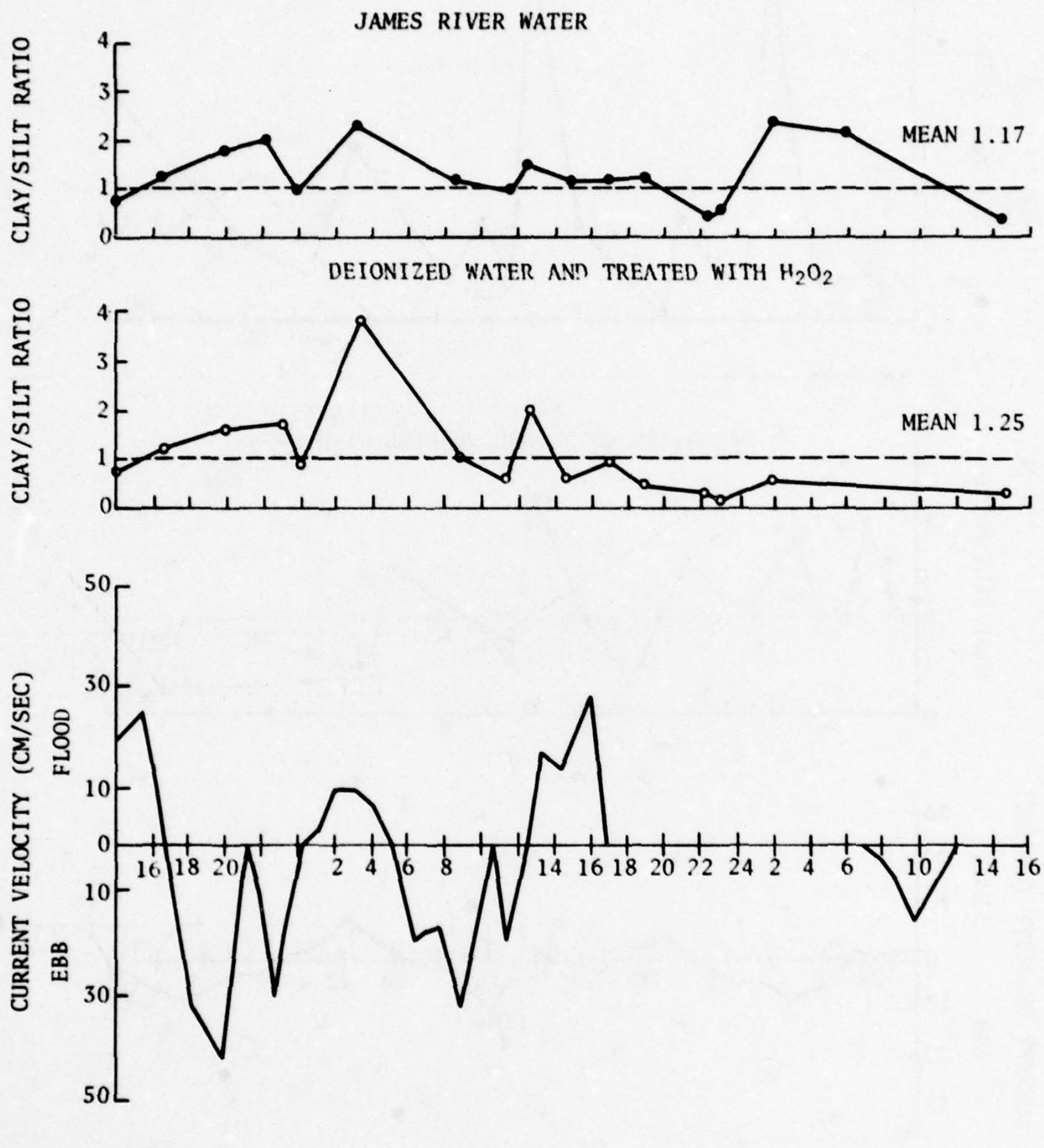


Figure 20. Naturally and artificially dispersed suspended sediments plotted as clay/silt ratios in order to emphasize the periods when the weight percent of clay (<2μ) was greater than the percent silt. Data are for January 8-10, 1977 at site AP (Pipe), James River Artificial Habitat Development Site.

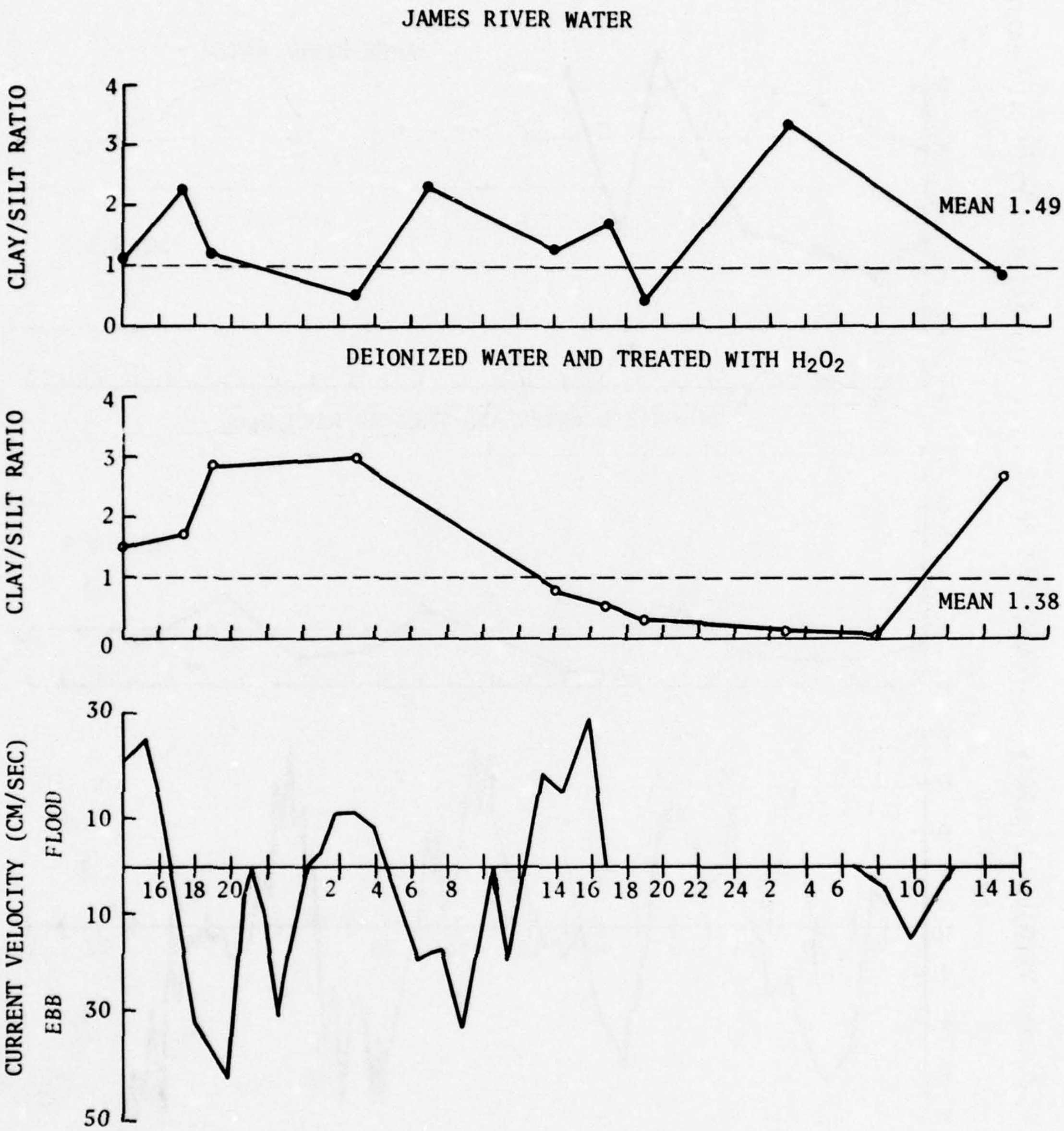


Figure 21. Naturally and artificially dispersed suspended sediments plotted as clay/silt ratios in order to emphasize the periods when the weight percent of clay (<2μ) was greater than the percent silt. Data are for January 8-10, 1977, at site AB (Breach), James River Artificial Habitat Development Site.

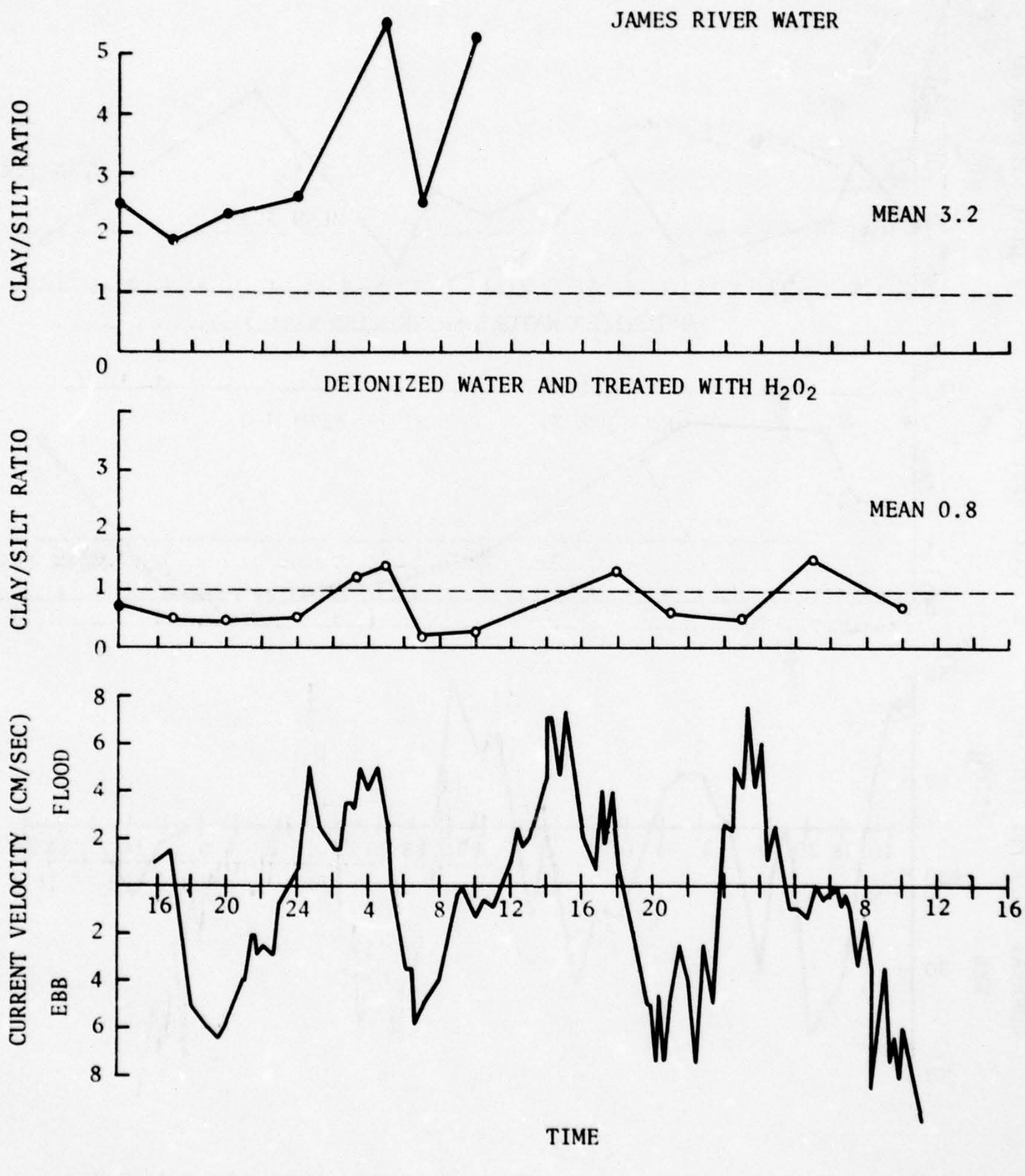


Figure 22. Naturally and artificially dispersed suspended sediments plotted as clay/silt ratios in order to emphasize the periods when the weight percent of clay (<2μ) was greater than the percent silt. Data are for January 8-10, 1977, at channel RL of the reference marsh.

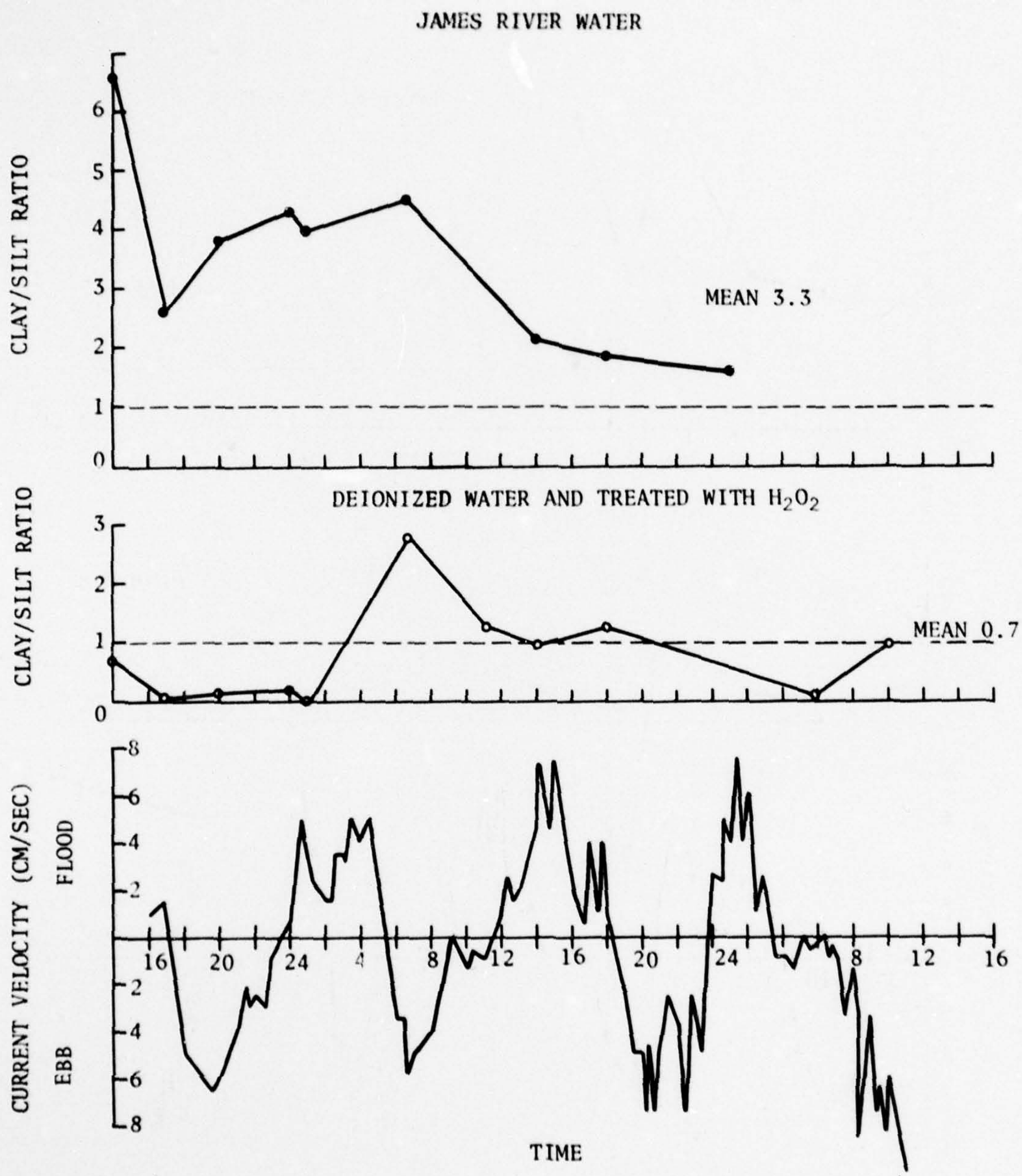


Figure 23. Naturally and artificially dispersed suspended sediments plotted as clay/silt ratios in order to emphasize the periods when the weight percent of clay (<2μ) was greater than the percent silt. Data are for January 8-10, 1977, at channel RS of the reference marsh.

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Habitat development field investigations, Windmill Point marsh development site, James River, Virginia; Appendix F: Environmental impacts of marsh development with dredged material: sediment and water quality; Volume II: Substrate and chemical flux characteristics of a dredged material marsh / by Donald D. Adams, Department of Chemistry, Wright State University, Dayton, Ohio, Dennis A. Darby and Randolph J. Young, Department of Physics and Geophysical Sciences and Institute of Oceanography, Old Dominion University, Norfolk, Virginia. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.
i, 72, [57] p. : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; D-77-23, Appendix F, v.2)
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Appendices A'-E' on microfiche in pocket.
Literature cited: p. 68-72.

(Continued on next card)

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1. Dredged material. 2. Dredged material disposal. 3. Environmental effects. 4. Field investigations. 5. Freshwater marshes. 6. Habitat development. 7. Habitats. 8. Interstitial water. 9. James River. 10. Marsh development. 11. Metal fluxes. 12. Nutrient fluxes. 13. Sediment. 14. Substrates. 15. Waste disposal sites. 16. Water quality. 17. Windmill Point.
I. Darby, Dennis A., joint author. II. Young, Randolph J., joint author. III. Old Dominion University. Dept. of Physics and Geophysical Sciences. IV. Old Dominion University. Institute of Oceanography. V. United States. Army. Corps of Engineers. VI. Wright State University. Dept. of Chemistry. VII. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; D-77-23 Appendix F, v.2.
TA7.W34 no.D-77-23 Appendix F v.2

DREDGED MATERIAL RESEARCH PROGRAM

TECHNICAL REPORT D-77-23

HABITAT DEVELOPMENT FIELD INVESTIGATIONS, WINDMILL POINT MARSH DEVELOPMENT SITE

JAMES RIVER, VIRGINIA

APPENDIX F: ENVIRONMENTAL IMPACTS OF MARSH DEVELOPMENT WITH DREDGED MATERIAL:

SEDIMENT AND WATER QUALITY

VOLUME II: SUBSTRATE AND CHEMICAL FLUX CHARACTERISTICS

OF A DREDGED MATERIAL MARSH

by

Donald D. Adams
Department of Chemistry, Wright State University, Dayton, Ohio 45431

Dennis A. Darby and Randolph J. Young
Department of Physics and Geophysical Sciences and Institute of Oceanography
Old Dominion University, Norfolk, Virginia 23508

August 1978

Final Report

Draft Copy

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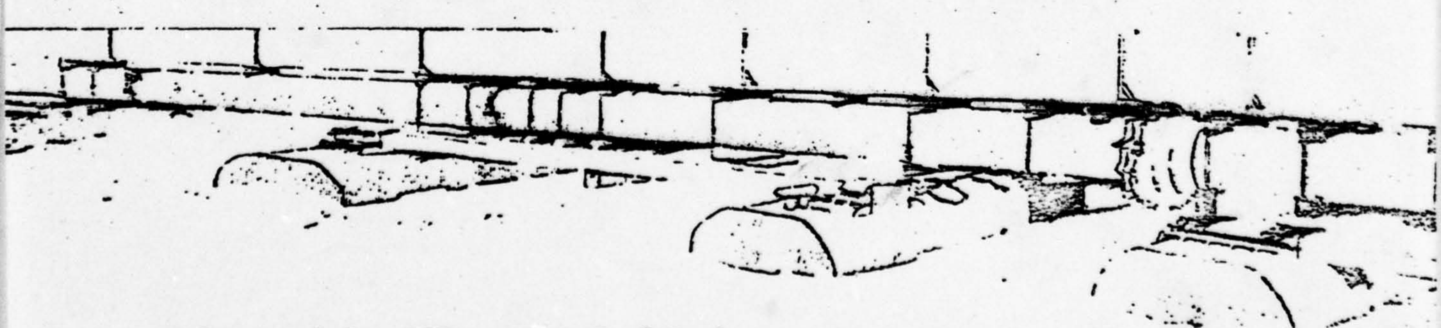

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APPENDIX A'

DATA PLOTS

(Figures A'1-A'111)

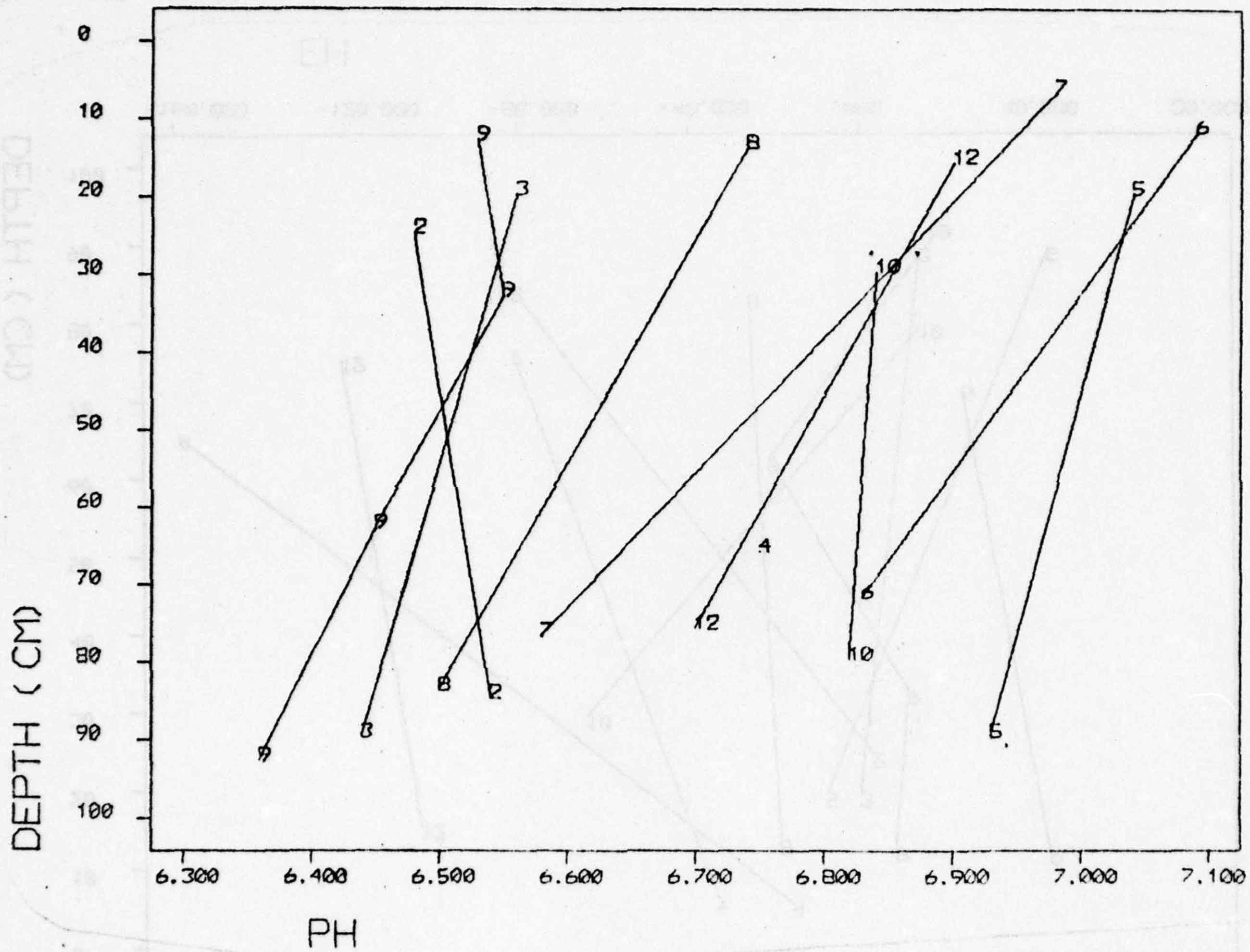

Figure A'1. Vertical depth distributions of sediment pH in ten channel cores near Windmill Point, James River, Virginia, in January 1975.

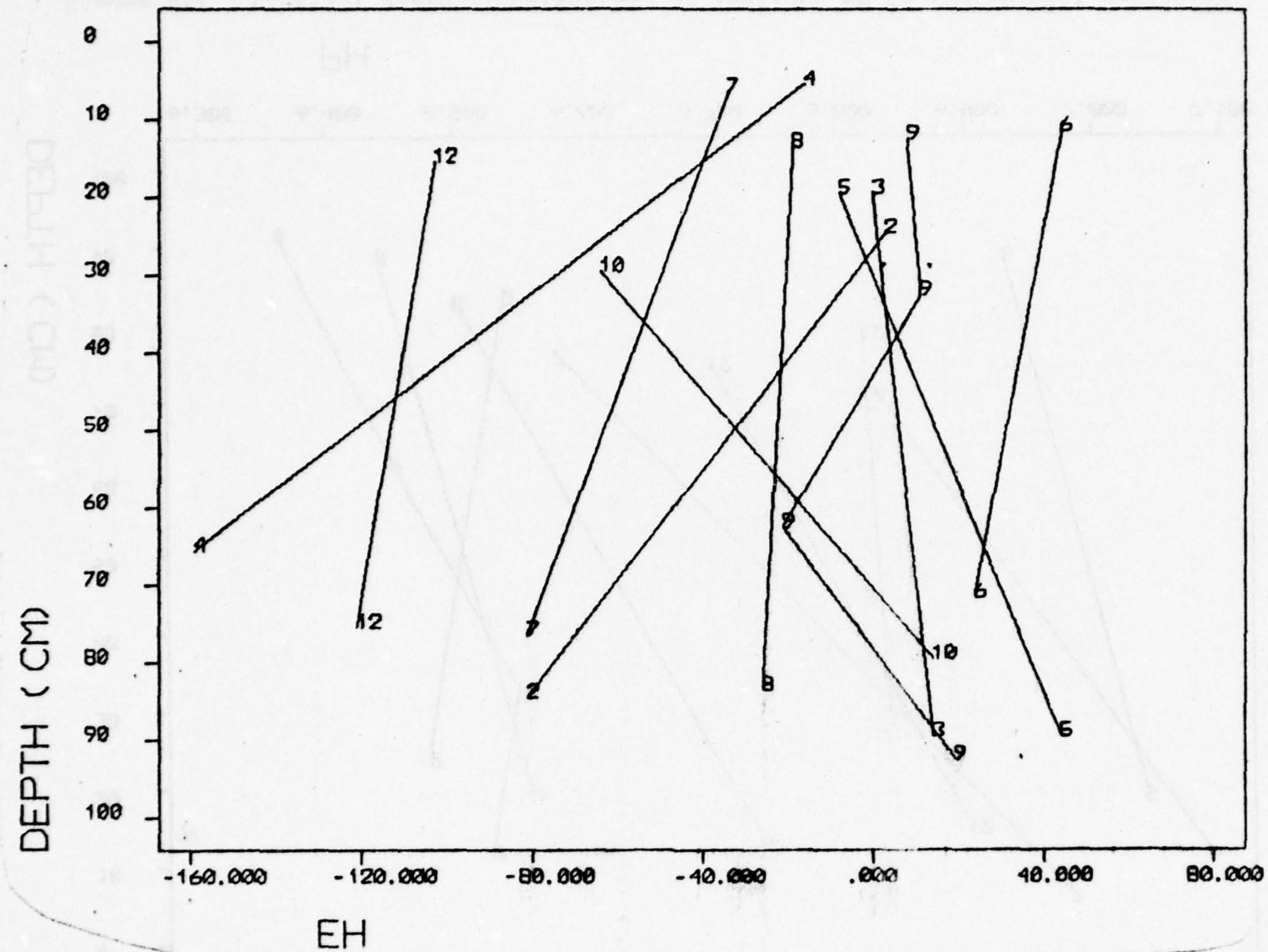

Figure A'2. Vertical depth distributions of sediment redox potential in ten channel cores near Windmill Point, James River, Virginia, in January 1975.

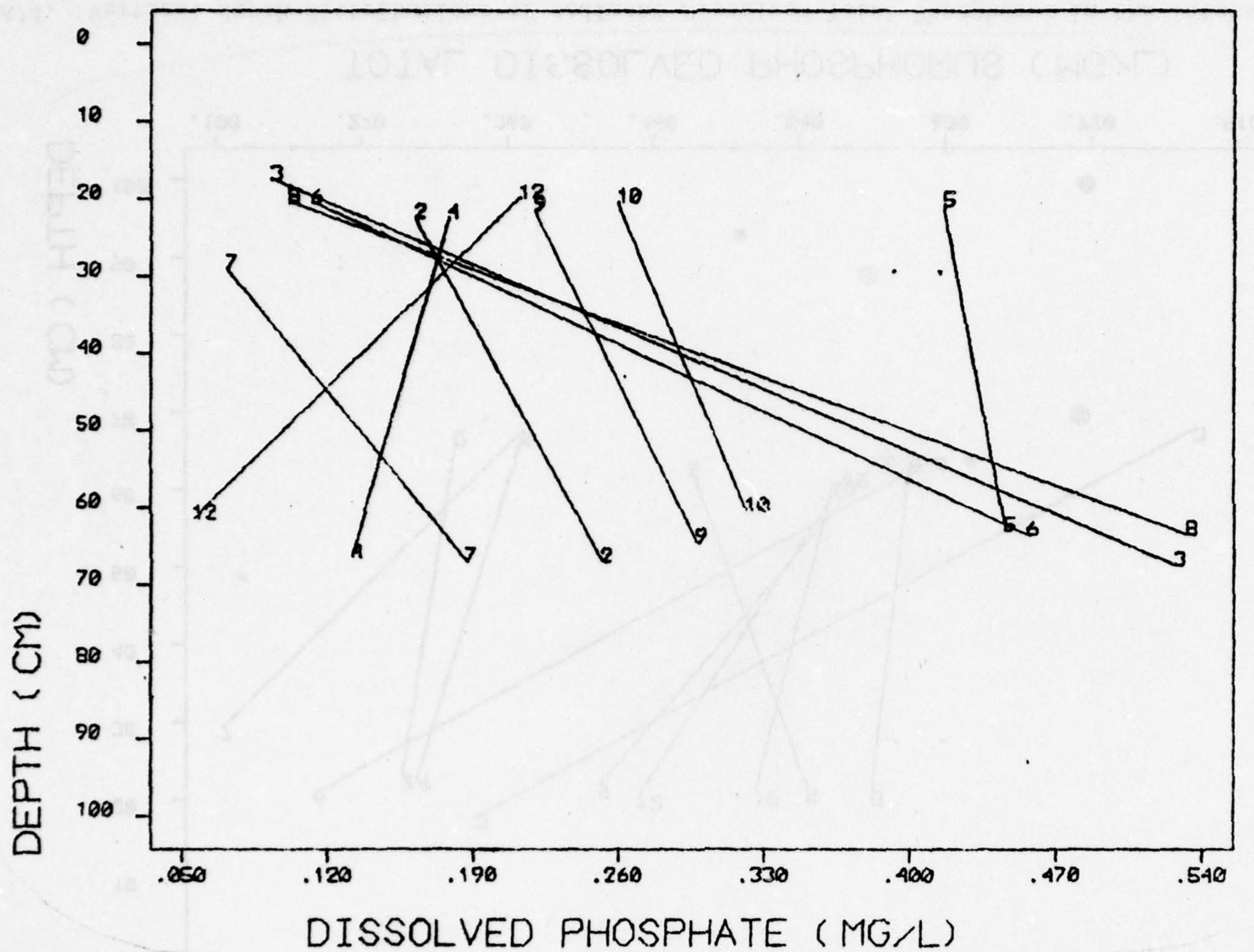

Figure A'3. Vertical depth distributions of sediment Dissolved Phosphate in the interstitial water of ten channel cores near Windmill Point, James River, Virginia in January 1975.

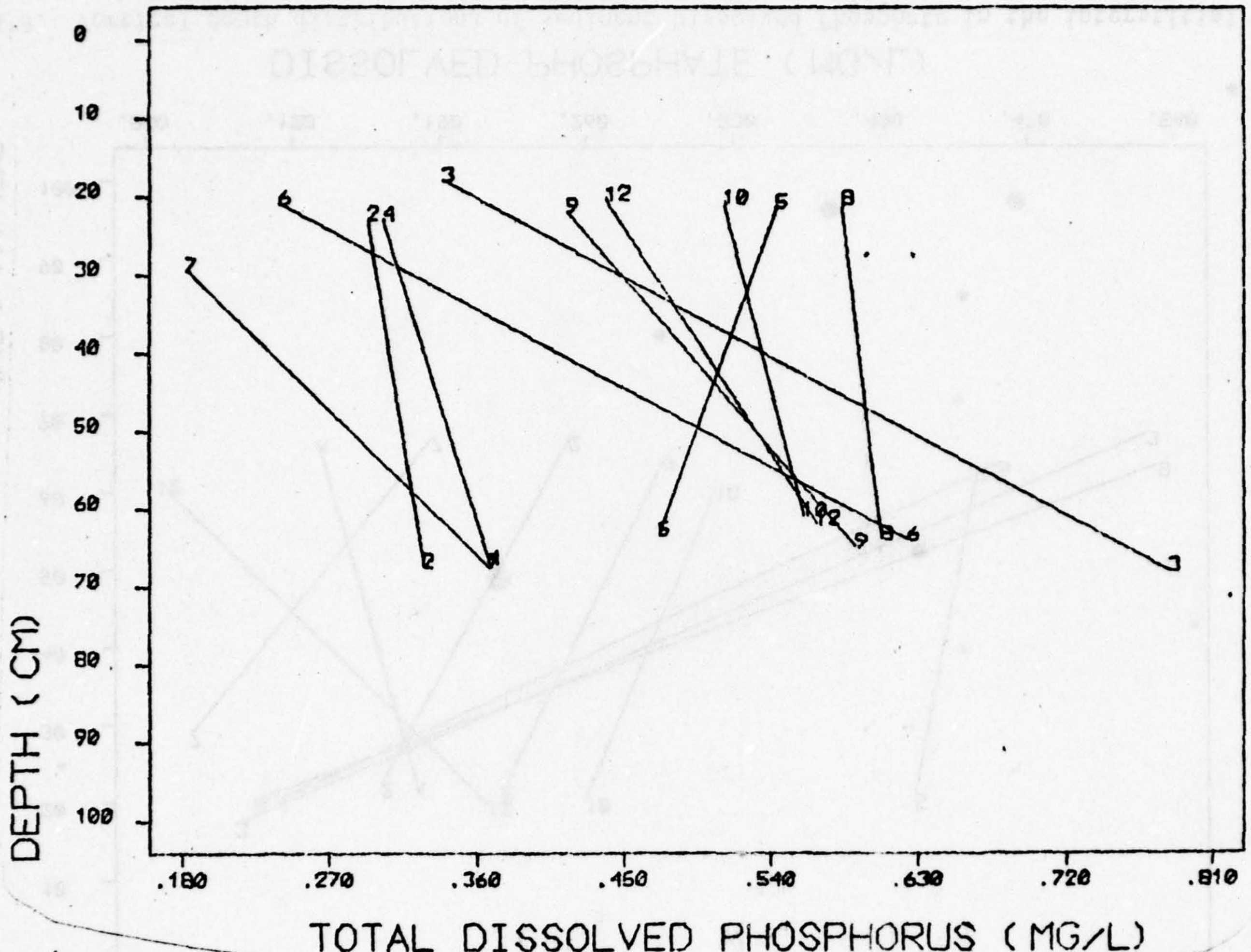

Figure A'4. Vertical depth distributions of sediment Dissolved Total Phosphorus in the interstitial water of ten channel cores near Windmill Point, James River, Virginia, in January 1975.

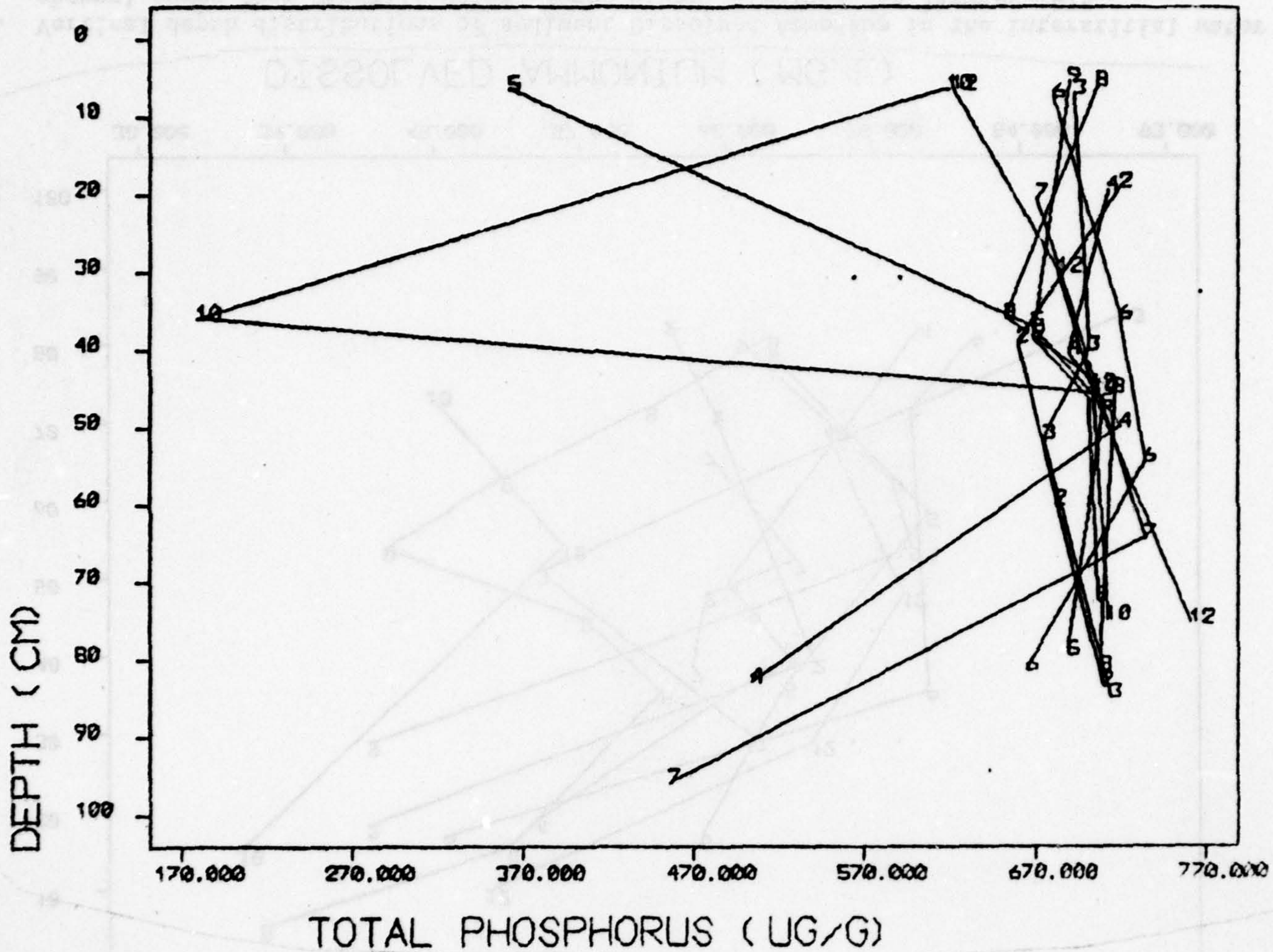

Figure A'5. Vertical depth distributions of sediment bulk Total Phosphorus in ten channel cores near Windmill Point, James River, Virginia, in January 1975.

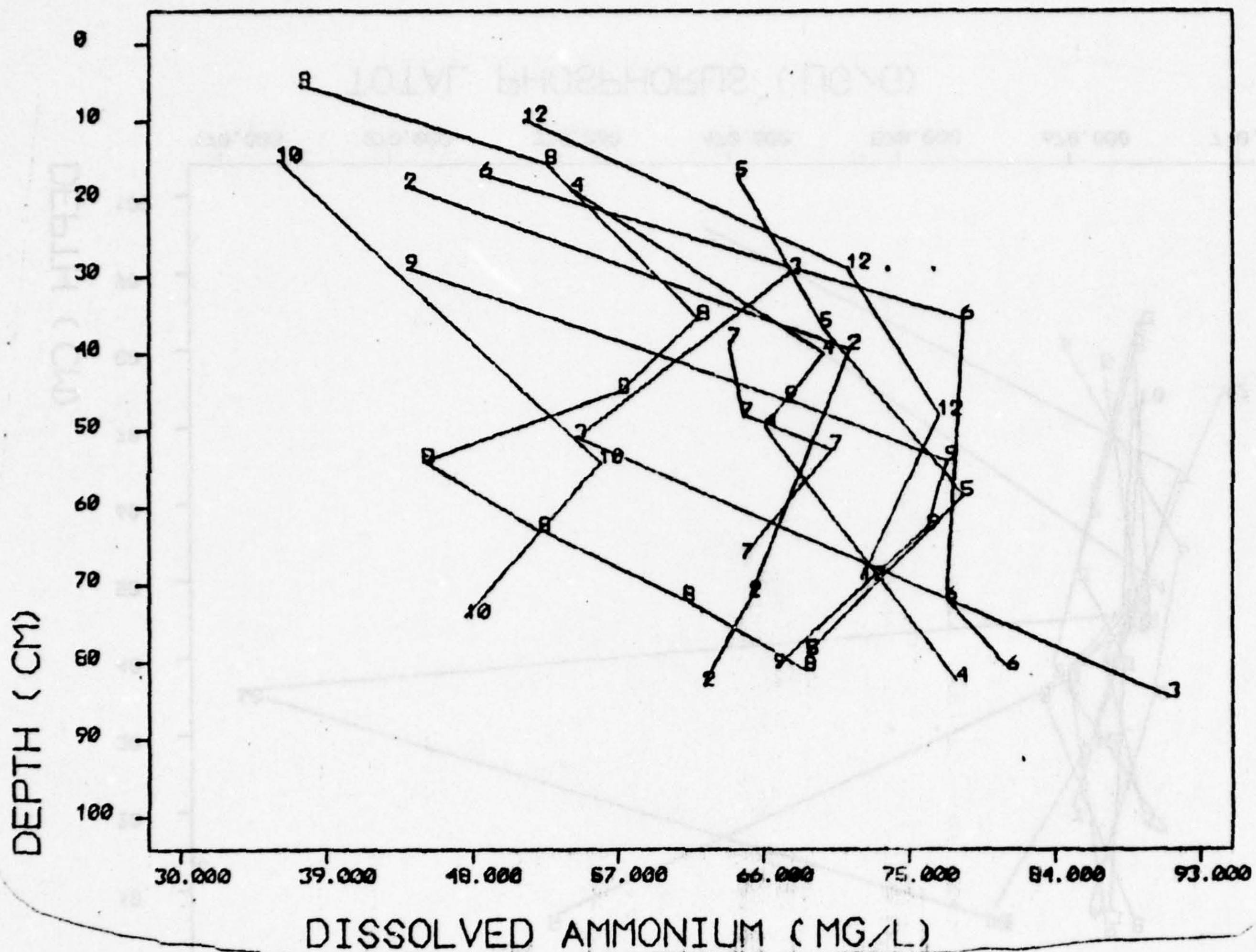

Figure A'6. Vertical depth distributions of sediment Dissolved Ammonium in the interstitial water of ten channel cores near Windmill Point, James River, Virginia, in January 1975.

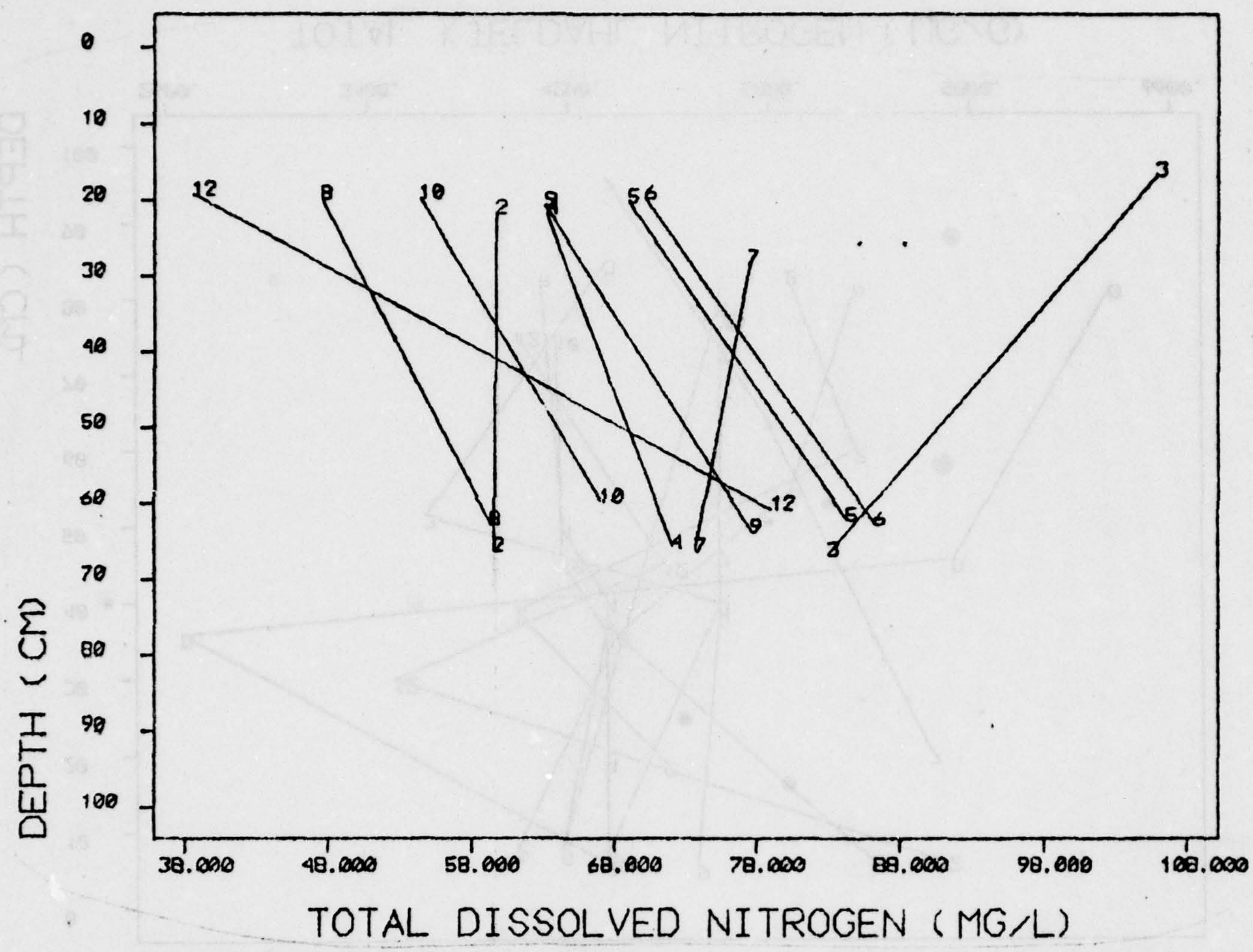

Figure A'7. Vertical depth distributions of sediment Dissolved Total Nitrogen in the interstitial water of ten channel cores near Windmill Point, James River, Virginia, in January 1975.

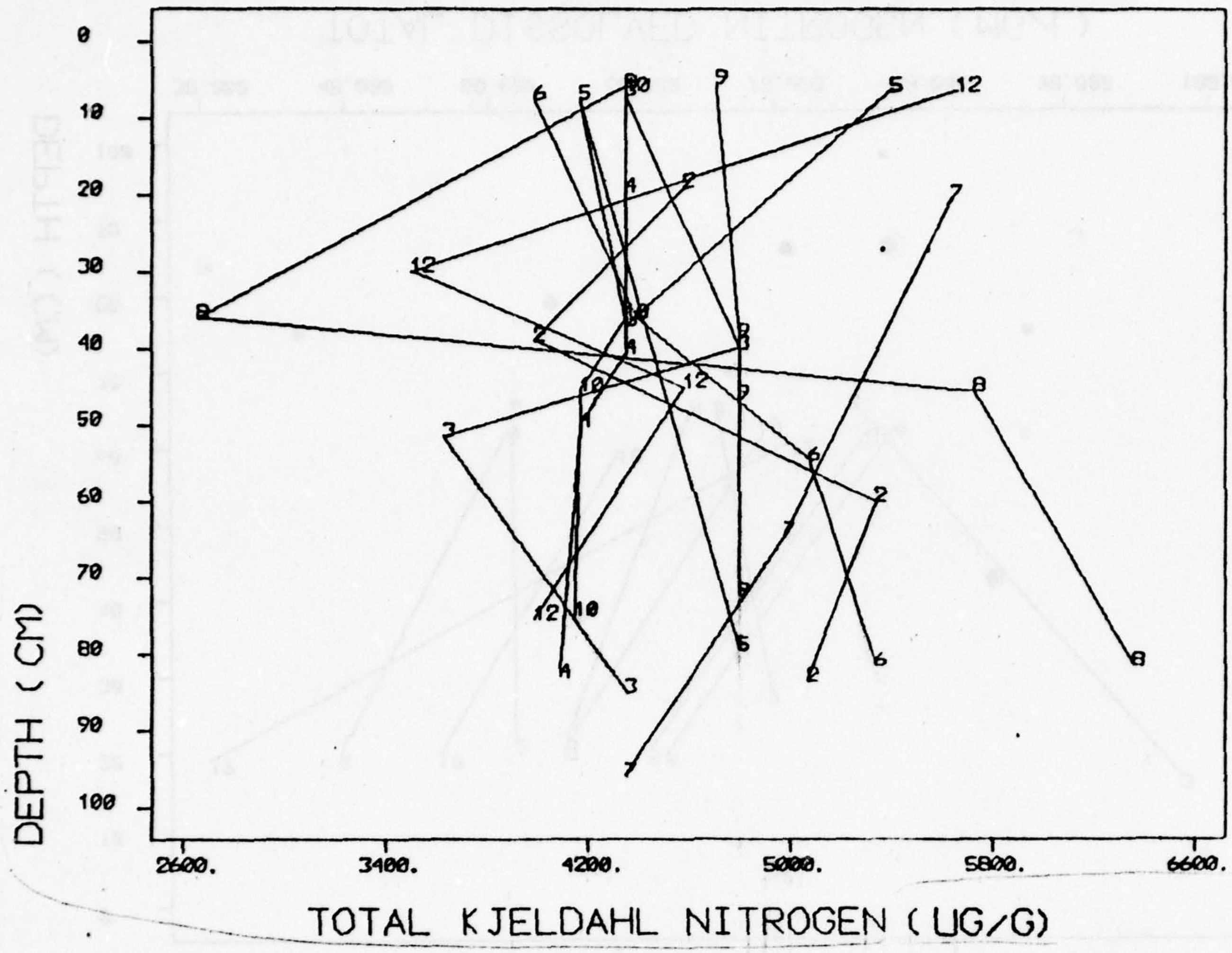

Figure A'8. Vertical depth distributions of sediment Bulk Total Kjeldahl Nitrogen in ten channel cores near Windmill Point, James River, Virginia, in January 1975.

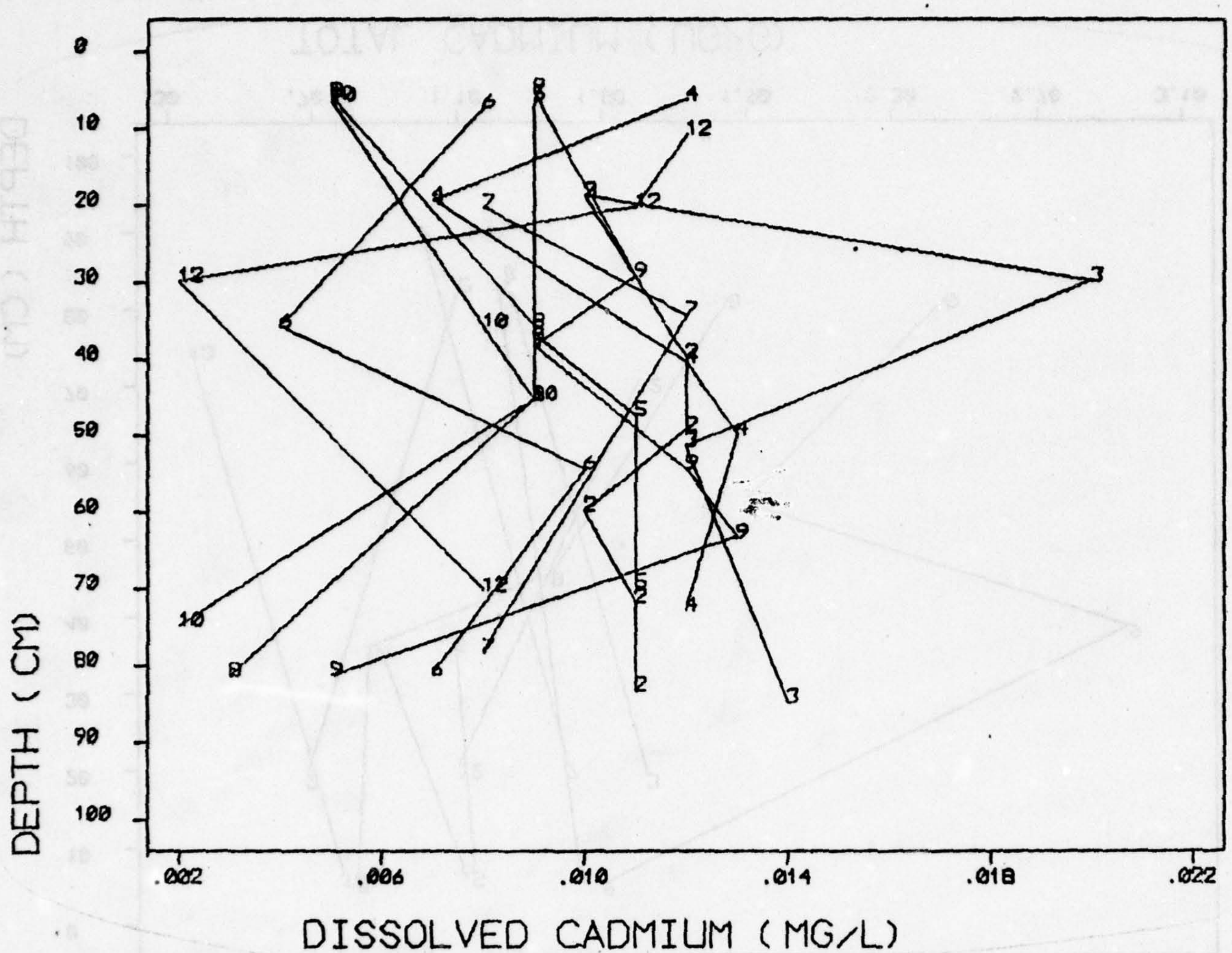

Figure A'9. Vertical depth distributions of sediment Dissolved Cadmium in the interstitial water of ten channel cores near Windmill Point, James River, Virginia in January 1975.

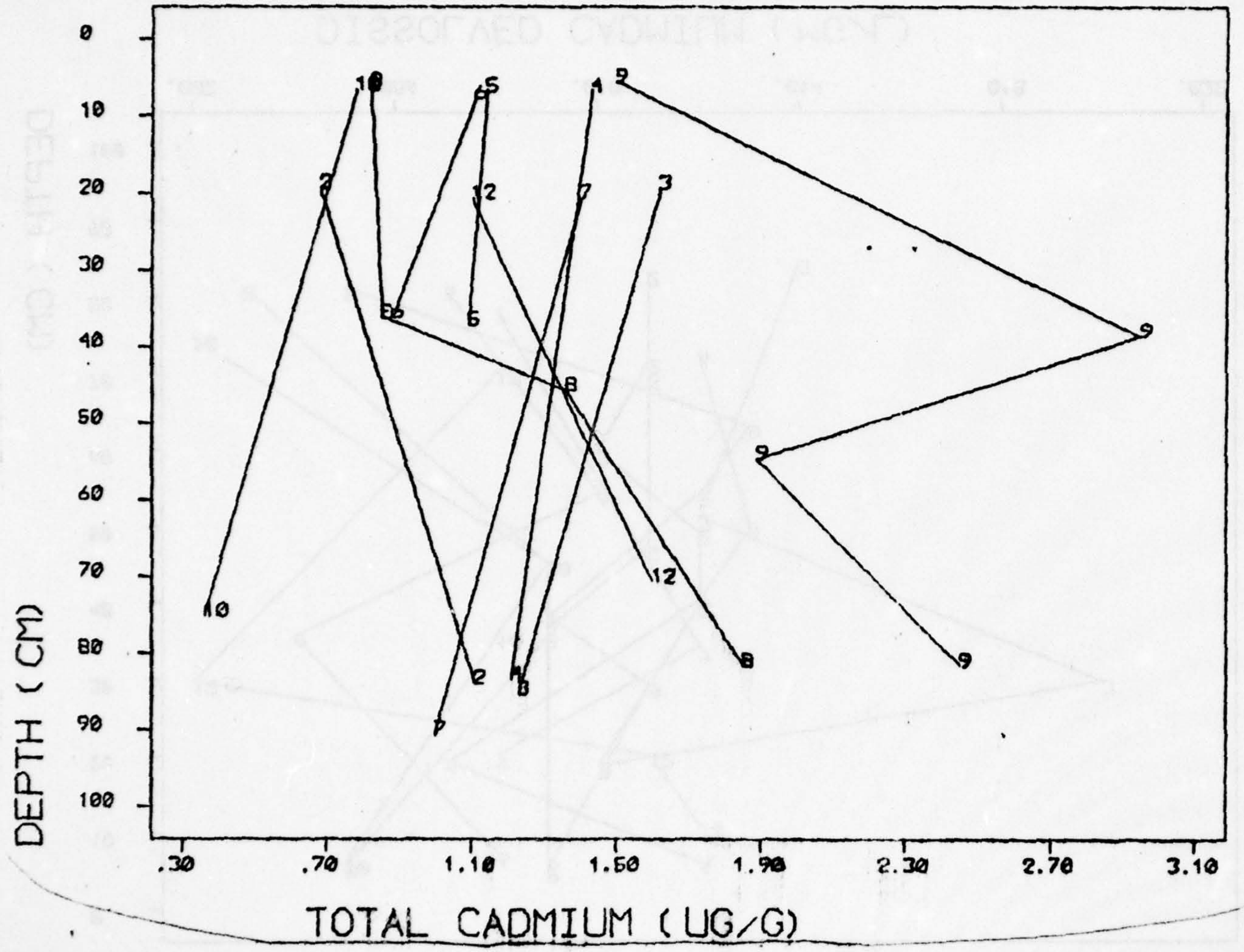

Figure A'10. Vertical depth distributions of sediment bulk Total Cadmium in ten channel cores near Windmill Point, James River, Virginia, in January 1975.

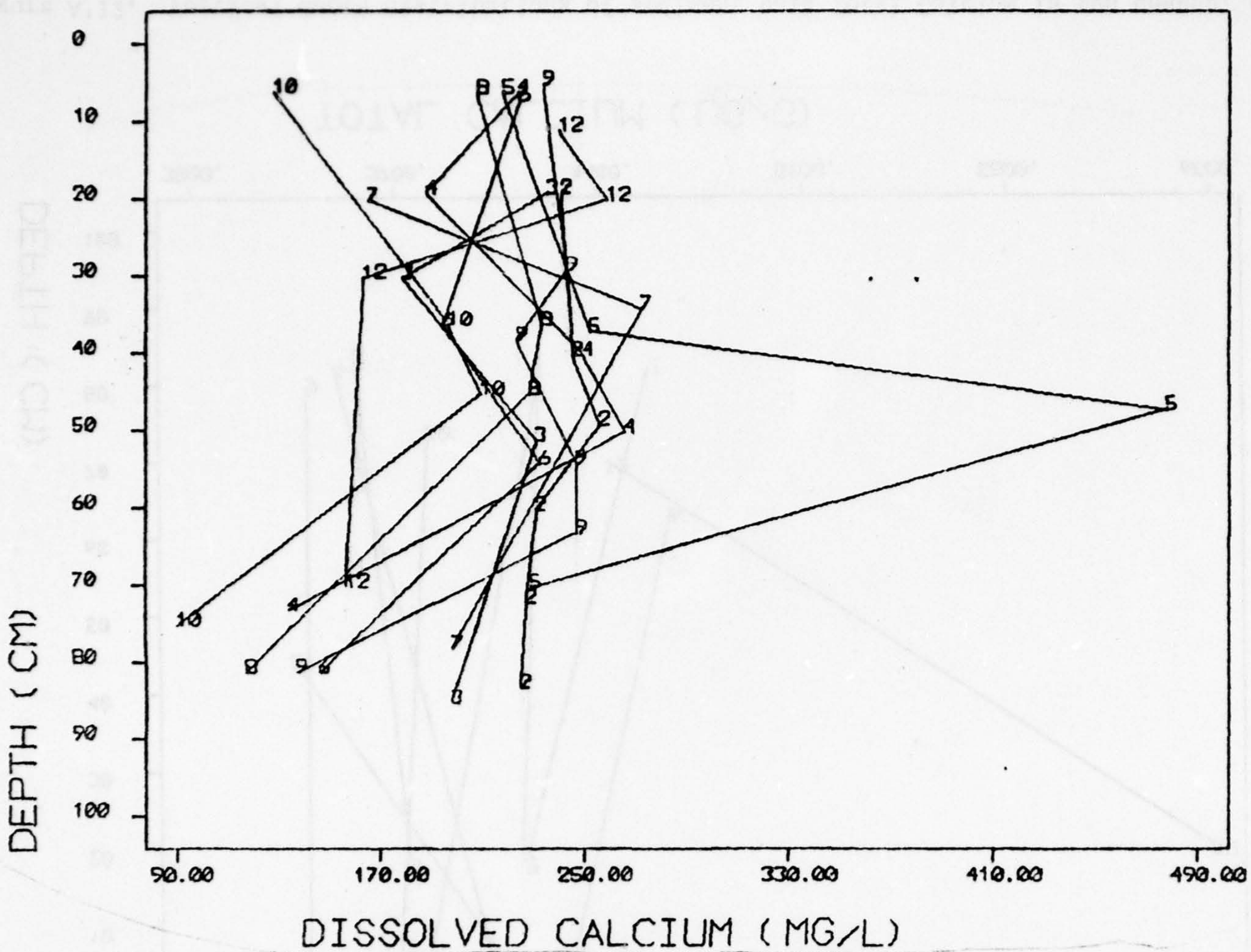

Figure A'11. Vertical depth distributions of sediment Dissolved Calcium in the interstitial water of ten channel cores near Windmill Point, James River, Virginia, in January 1975.

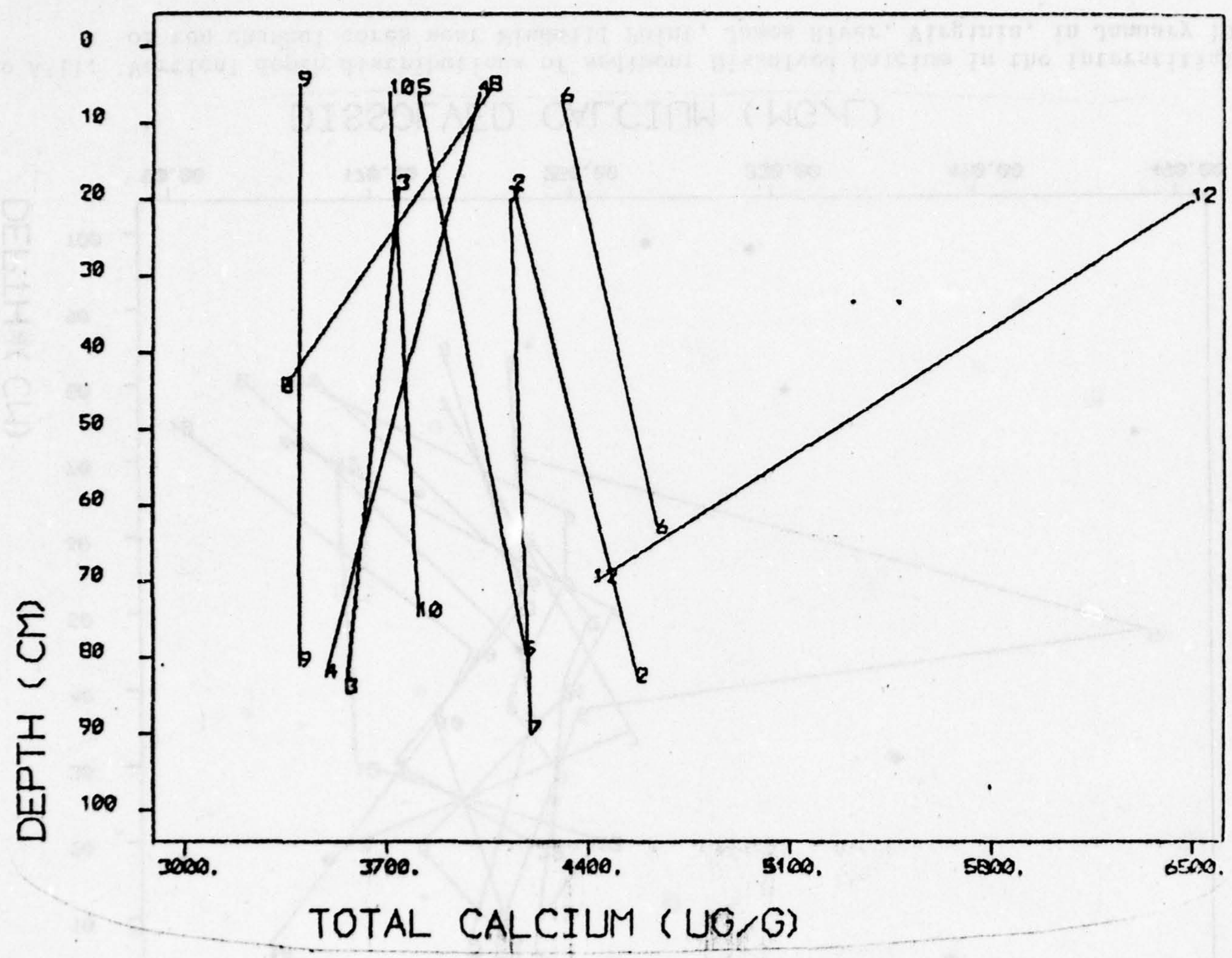

Figure A'12. Vertical depth distributions of sediment bulk Total Calcium in ten channel cores near Windmill Point, James River, Virginia, in January 1975.

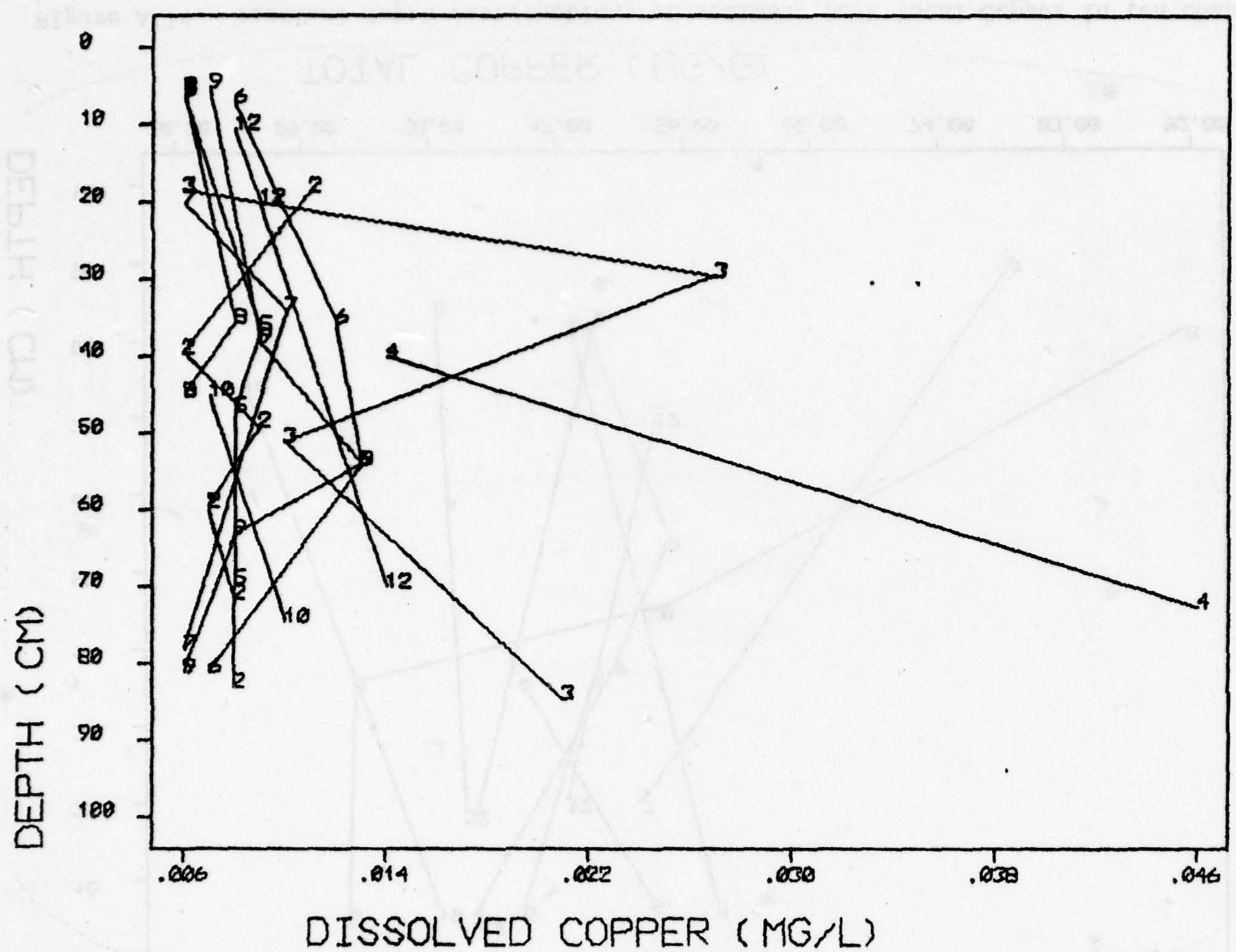

Figure A'13. Vertical depth distributions of sediment Dissolved Copper in the interstitial water of ten channel cores near Windmill Point, James River, Virginia, in January 1975.

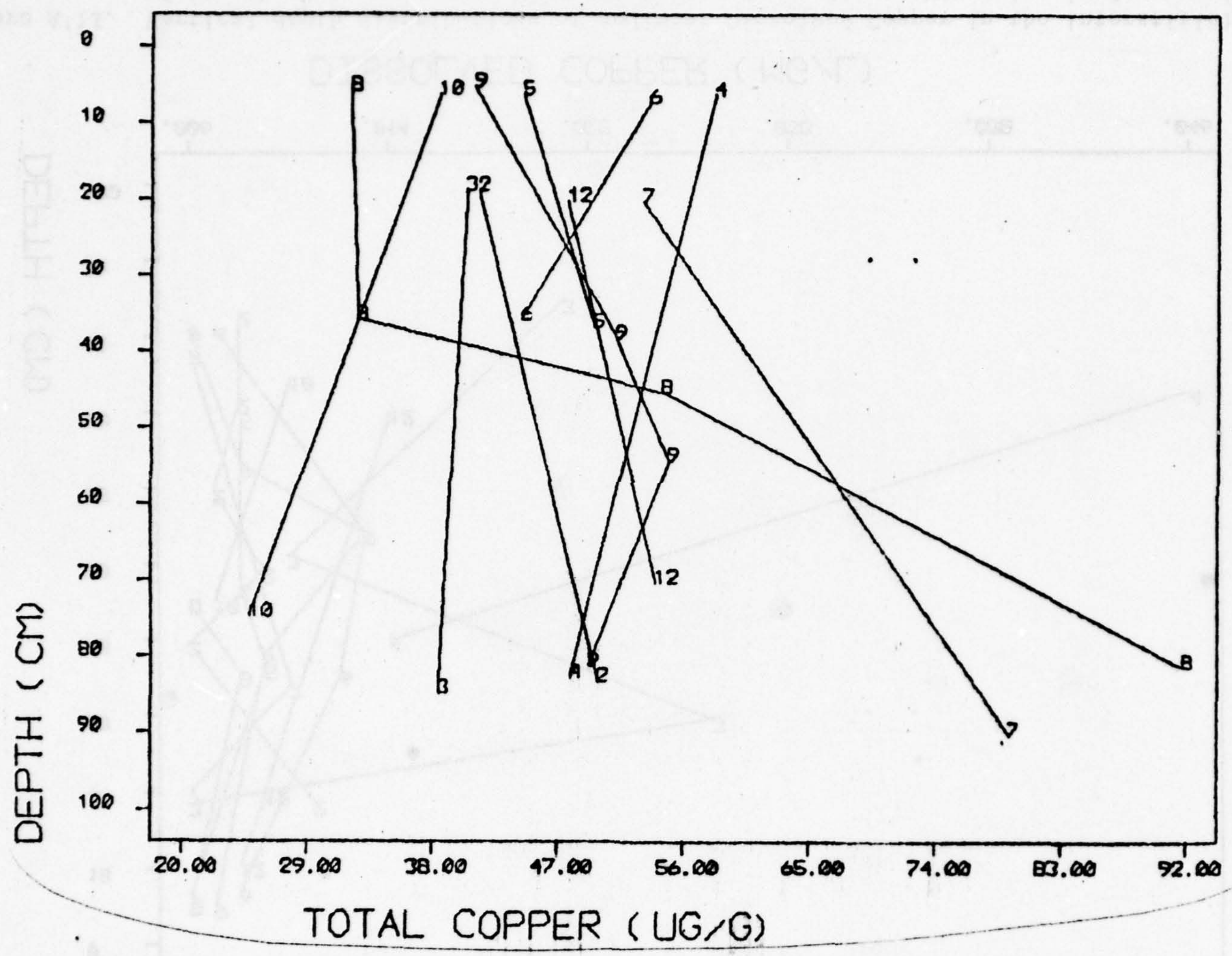

Figure A'14. Vertical depth distributions of sediment Bulk Total Copper in ten channel cores near Windmill Point, James River, Virginia, in January 1975.

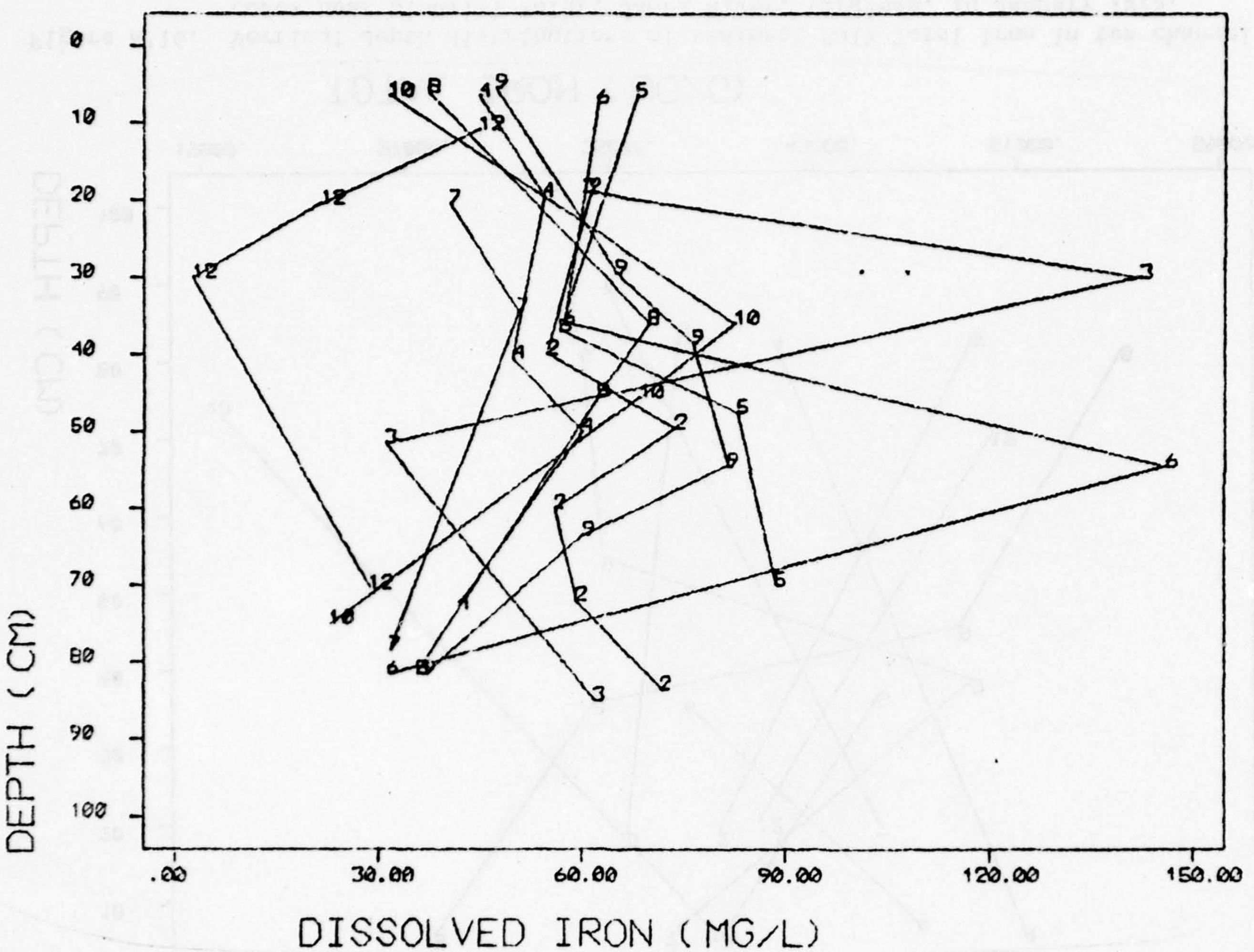

Figure A'15. Vertical depth distributions of sediment Dissolved Iron in the interstitial water of ten channel cores, near Windmill Point, James River, Virginia, in January 1975.

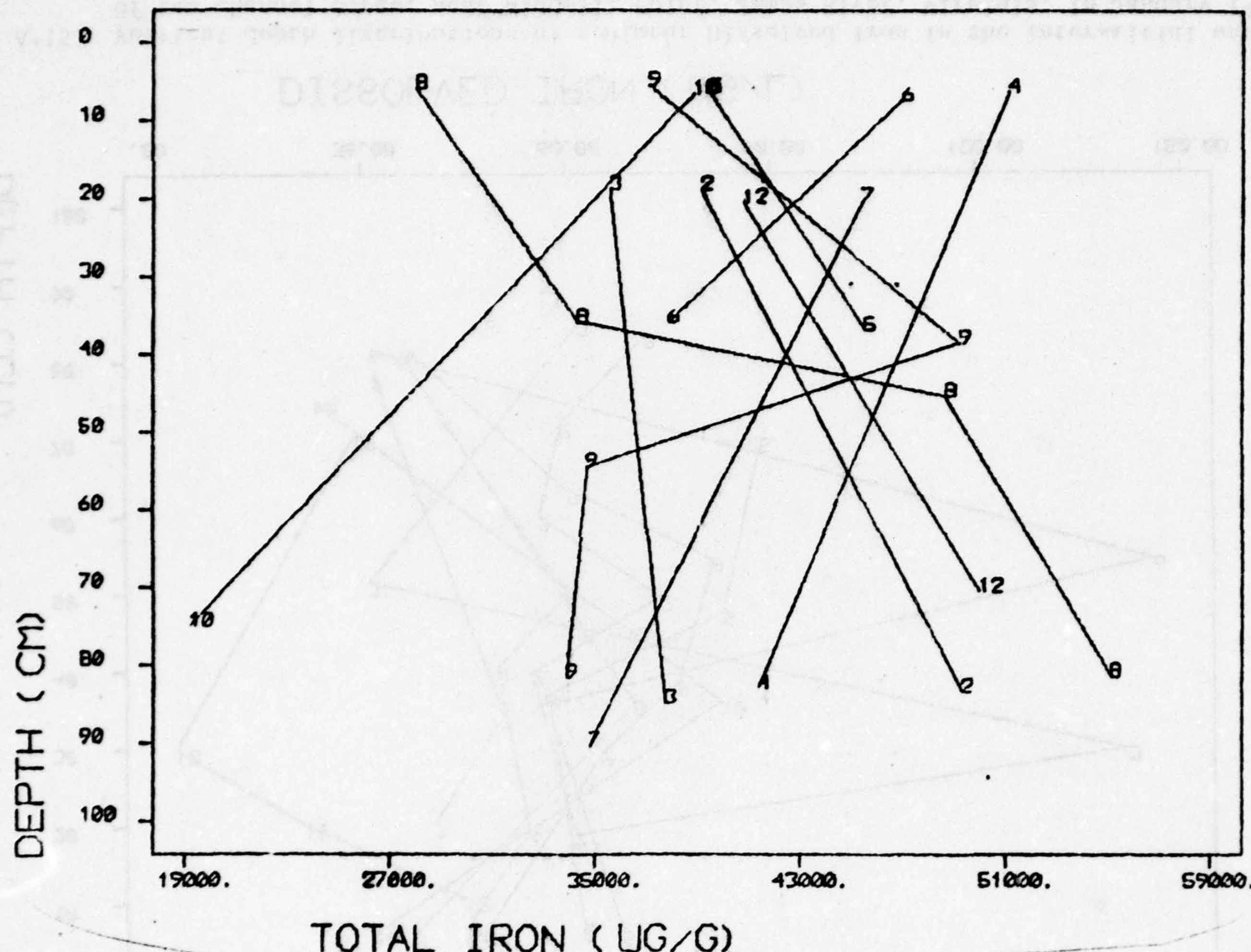

Figure A'16. Vertical depth distributions of sediment Bulk Total Iron in ten channel cores near Windmill Point, James River, Virginia, in January 1975.

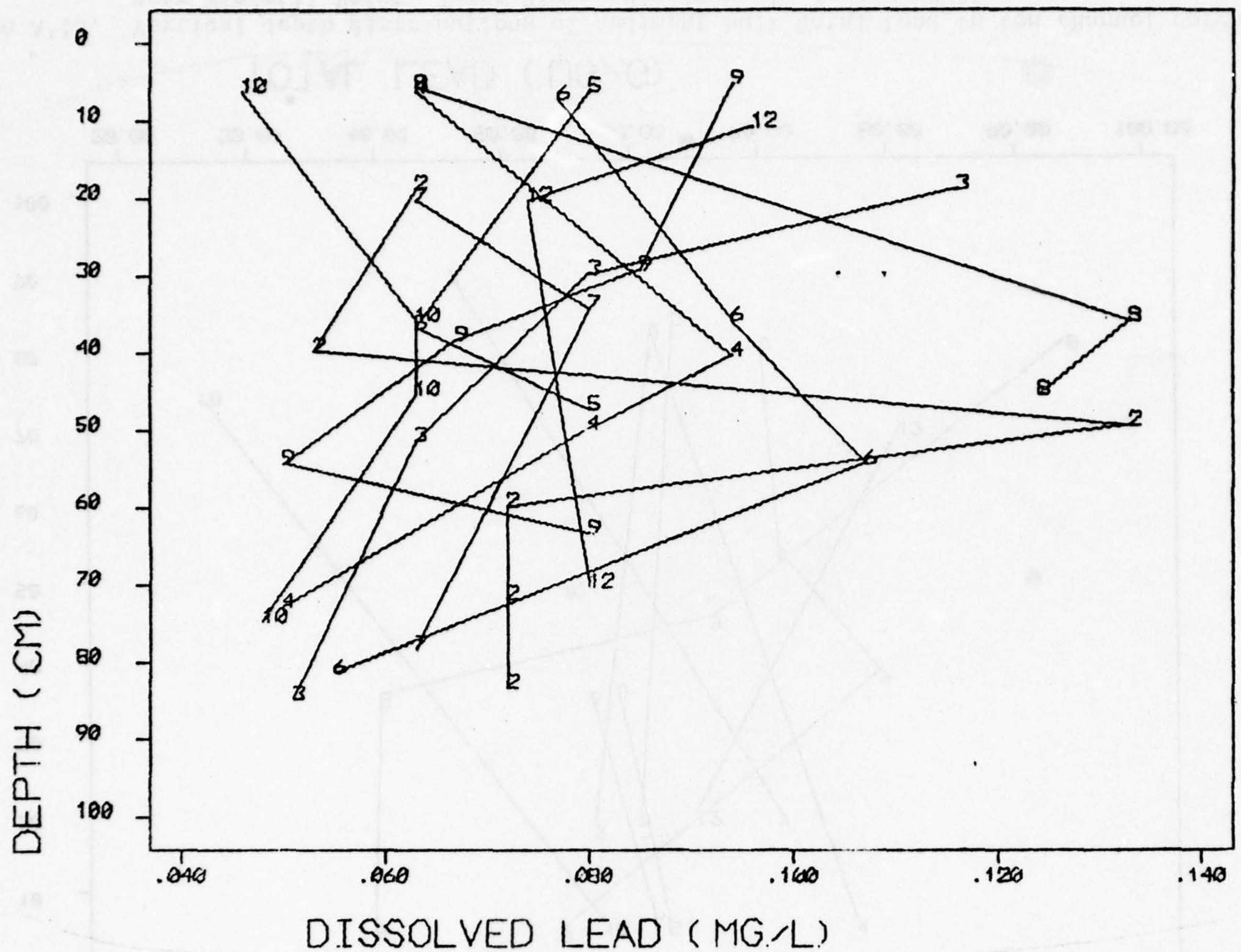

Figure A'17. Vertical depth distributions of sediment Dissolved Lead in the interstitial water of ten channel cores near Windmill Point, James River, Virginia, in January 1975.

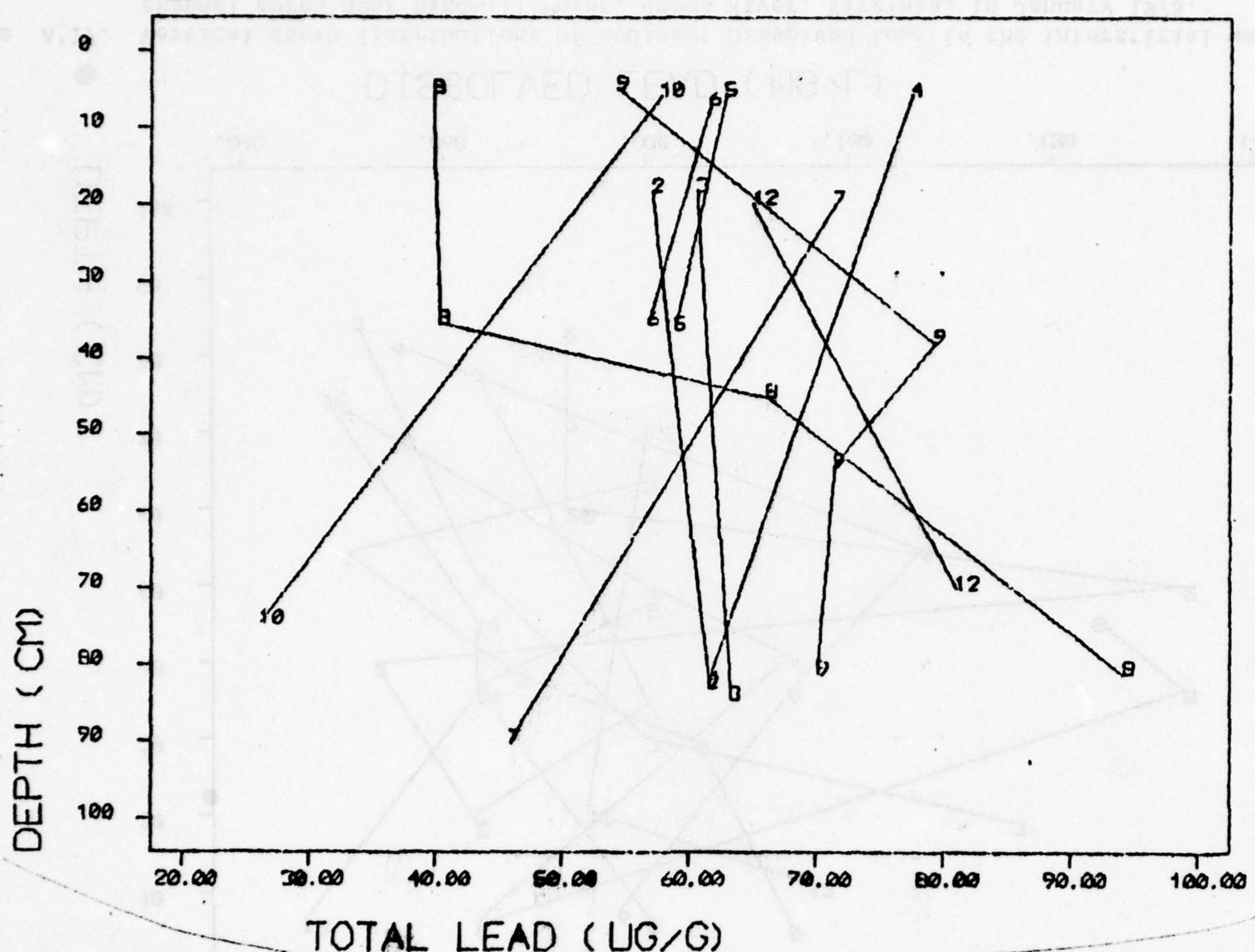

Figure A'18. Vertical depth distributions of sediment bulk Total Lead in ten channel cores near Windmill Point, James River, Virginia, in January 1975.

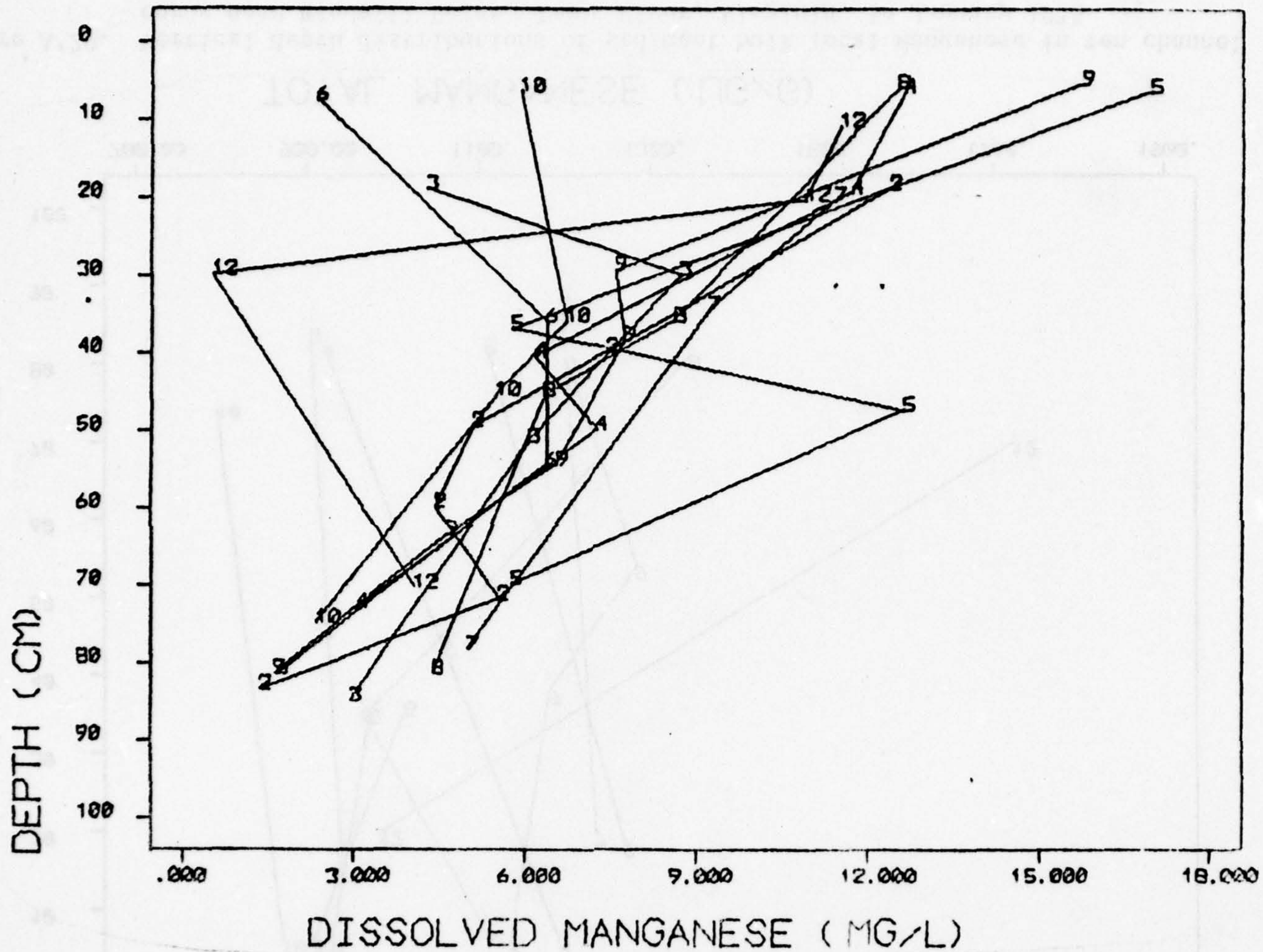

Figure A'19. Vertical depth distributions of sediment Dissolved Manganese in the interstitial water of ten channel cores near Windmill Point, James River, Virginia, in January 1975.

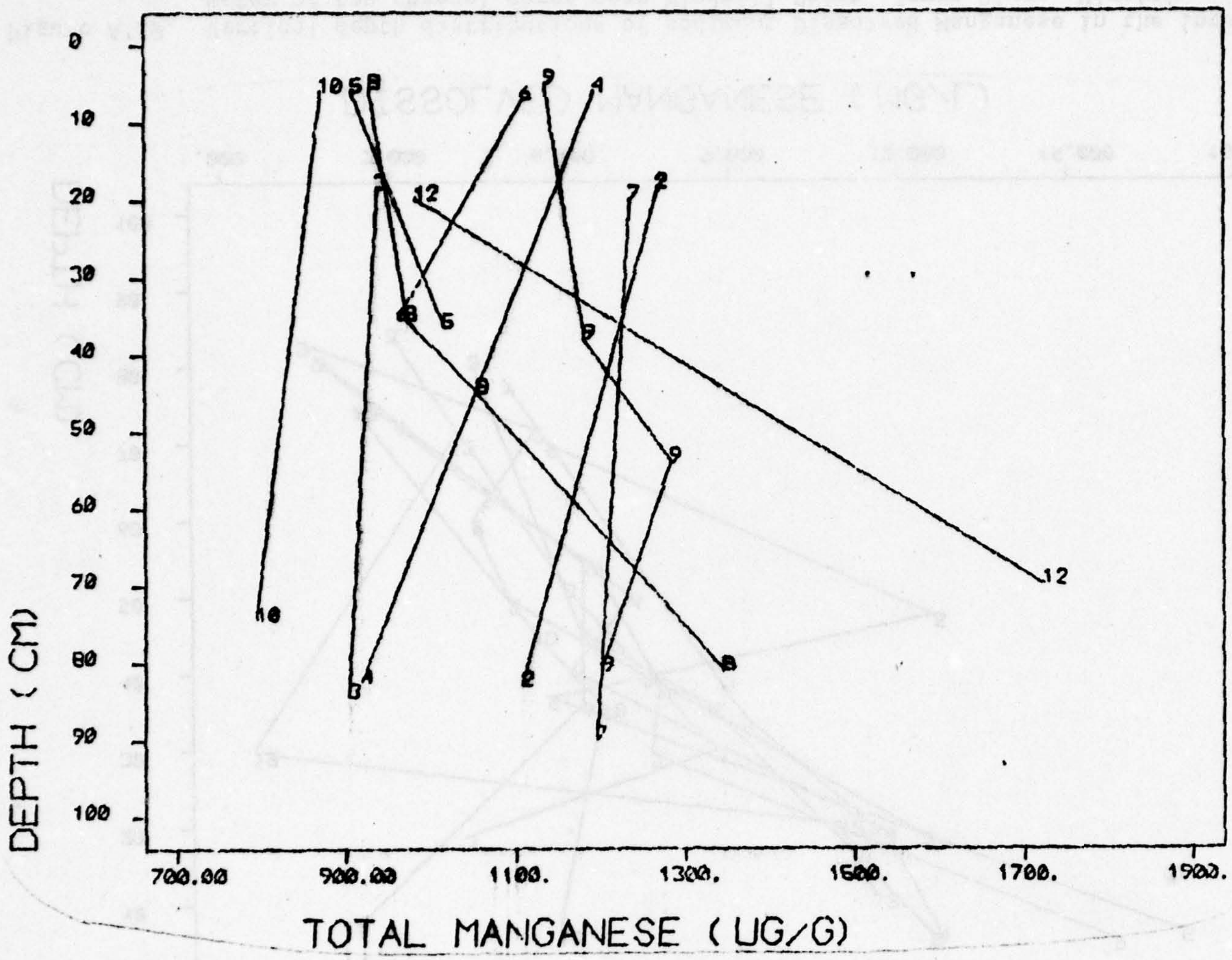

Figure A'20. Vertical depth distributions of sediment bulk Total Manganese in ten channel cores near Windmill Point, James River, Virginia, in January 1975.

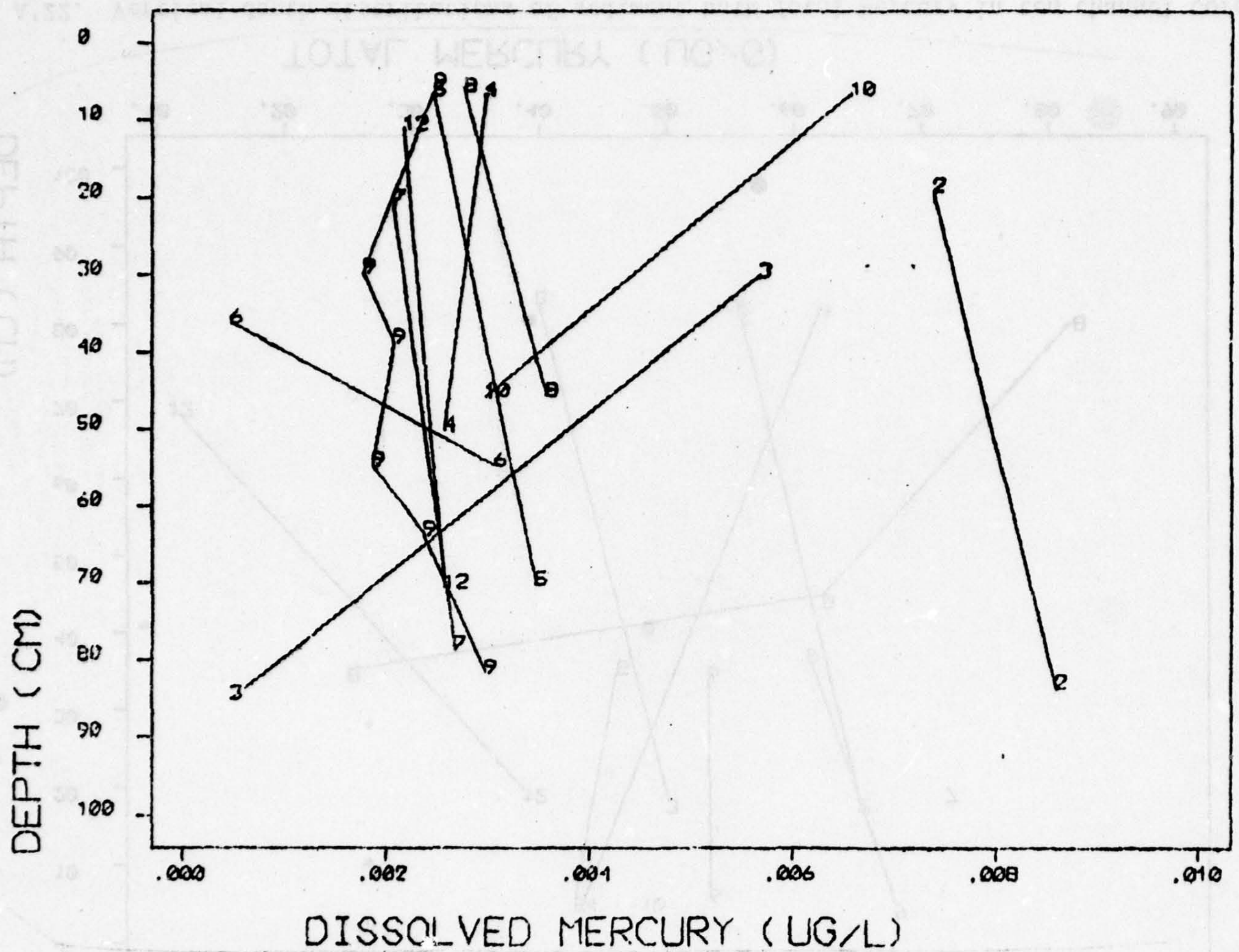

Figure A'21. Vertical depth distributions of sediment Dissolved Mercury in the interstitial water of ten channel cores near Windmill Point, James River, Virginia, in January 1975.

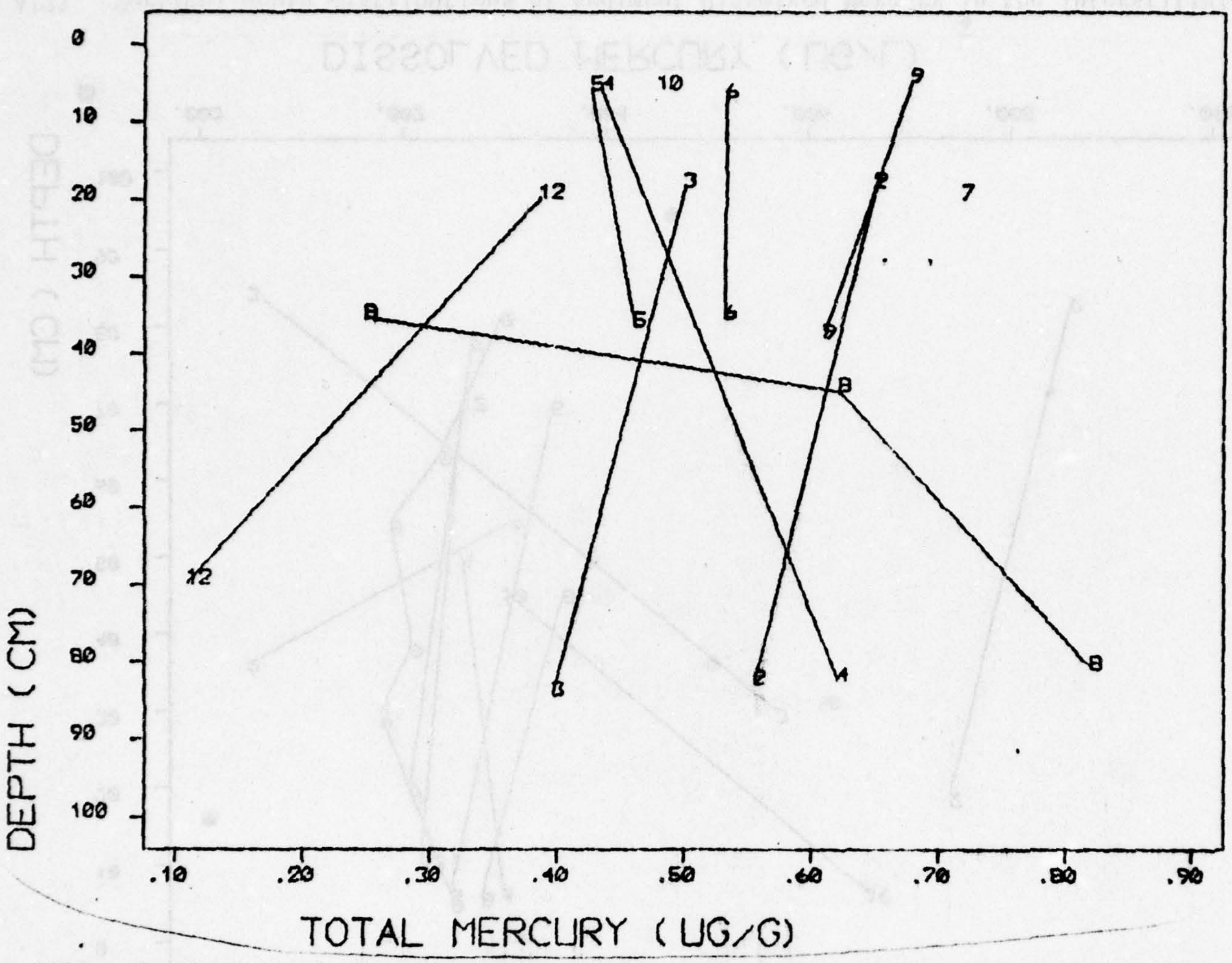

Figure A'22. Vertical depth distributions of sediment bulk Total Mercury in ten channel cores near Windmill Point, James River, Virginia, in January 1975.

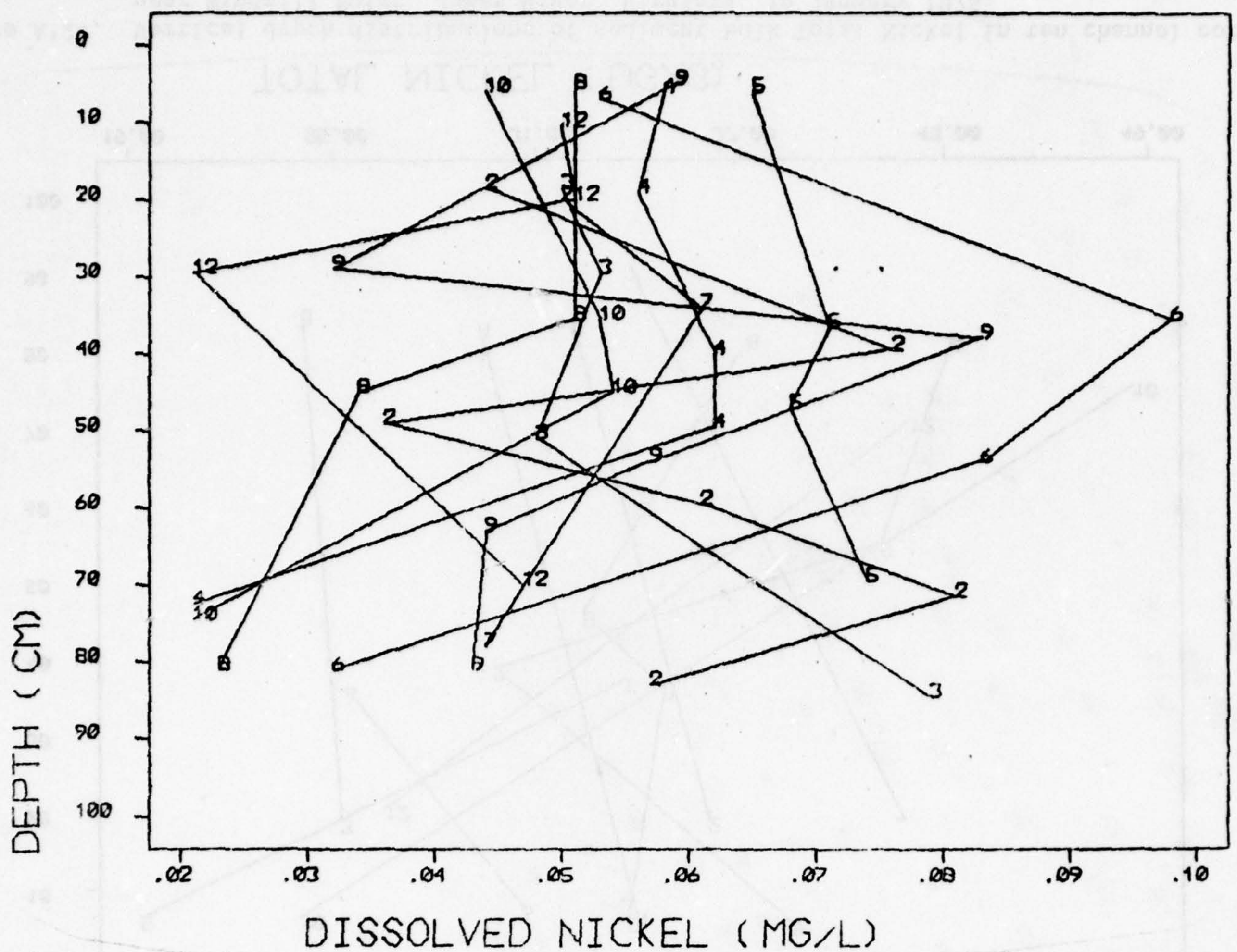

Figure A'23. Vertical depth distributions of sediment Dissolved Nickel in the interstitial water of ten channel cores near Windmill Point, James River, Virginia, in January 1975.

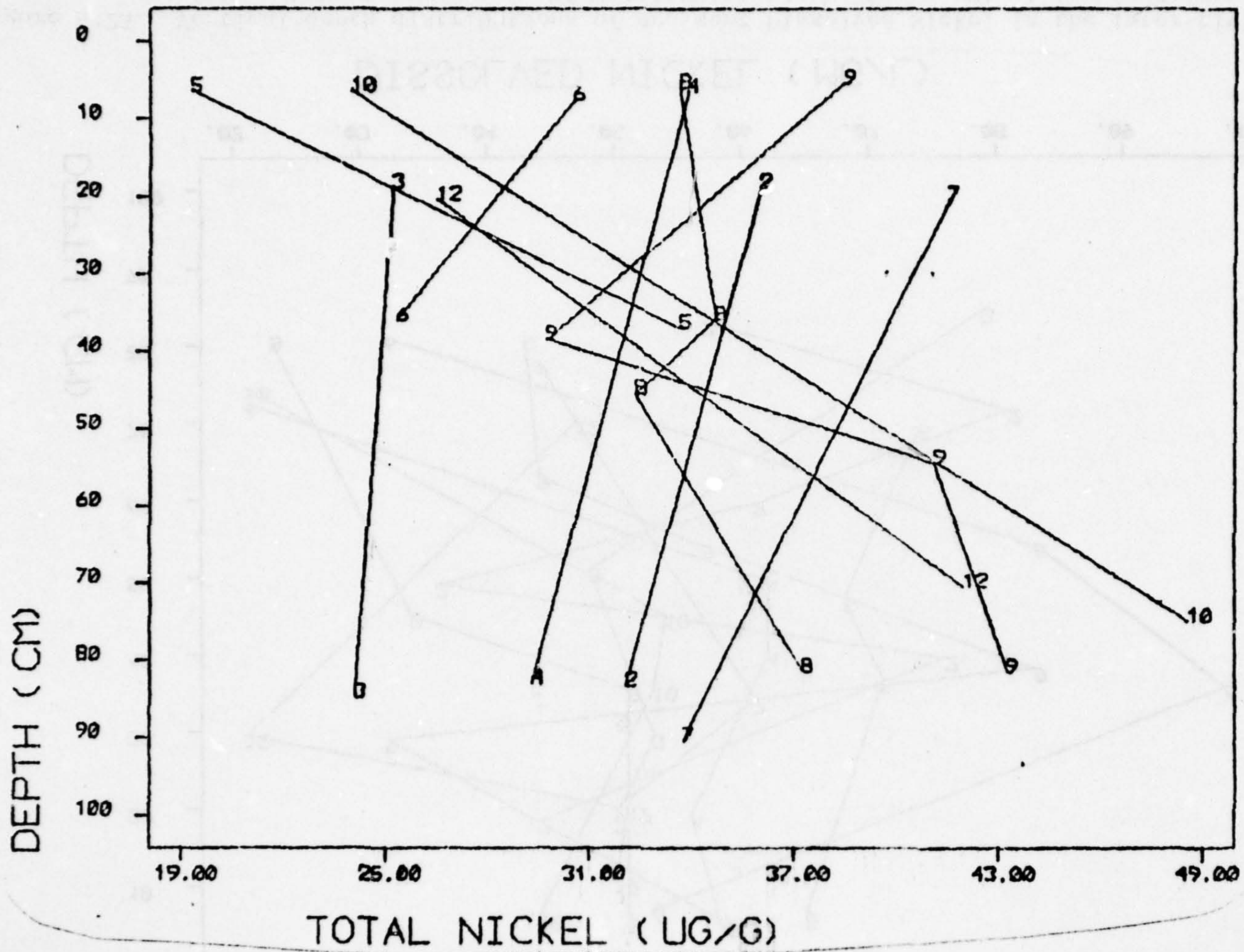

Figure A'24. Vertical depth distributions of sediment bulk Total Nickel in ten channel cores near Windmill Point, James River, Virginia, in January 1975.

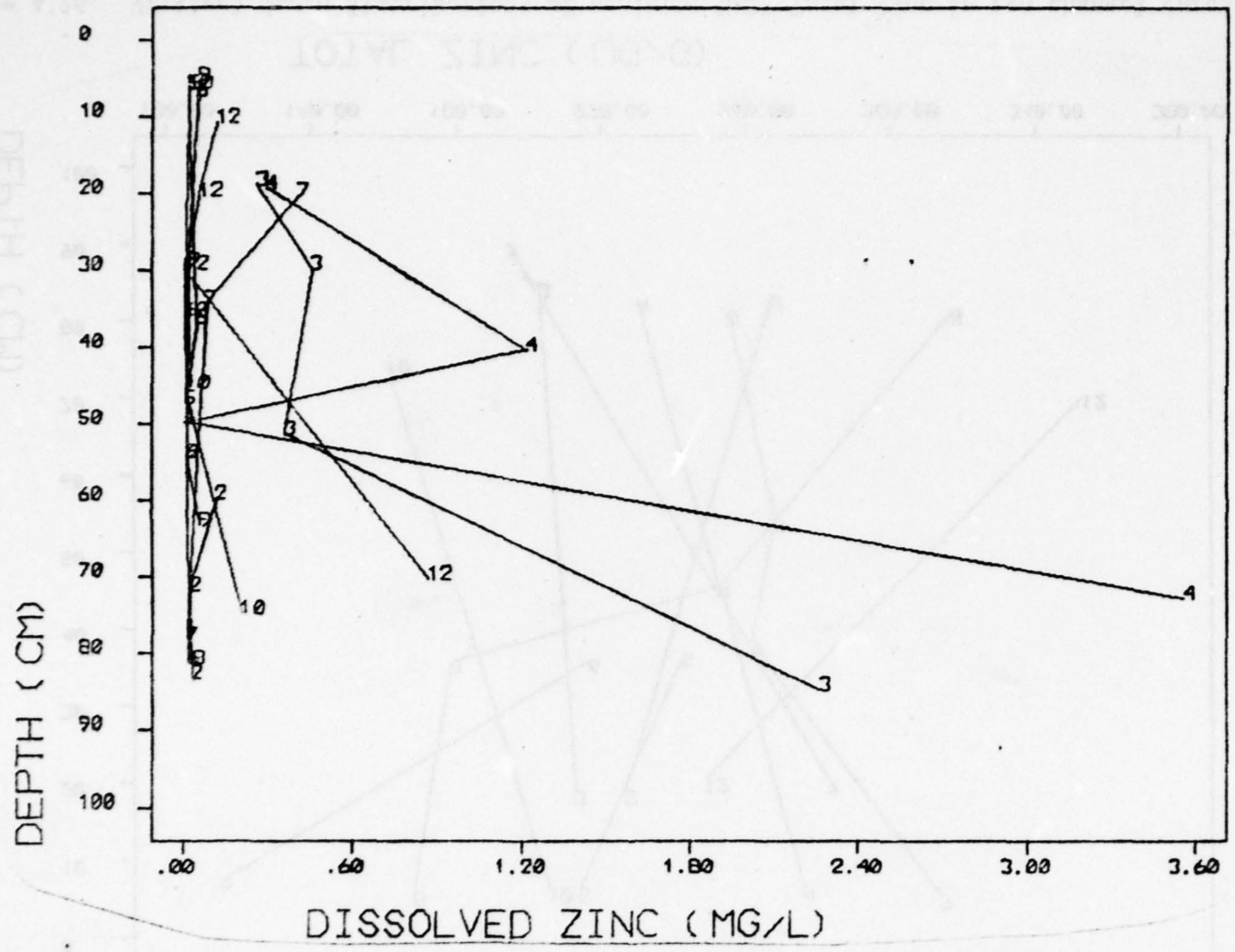

Figure A'25. Vertical depth distributions of sediment Dissolved Zinc in the interstitial water of ten channel cores near Windmill Point, James River, Virginia, in January 1975.

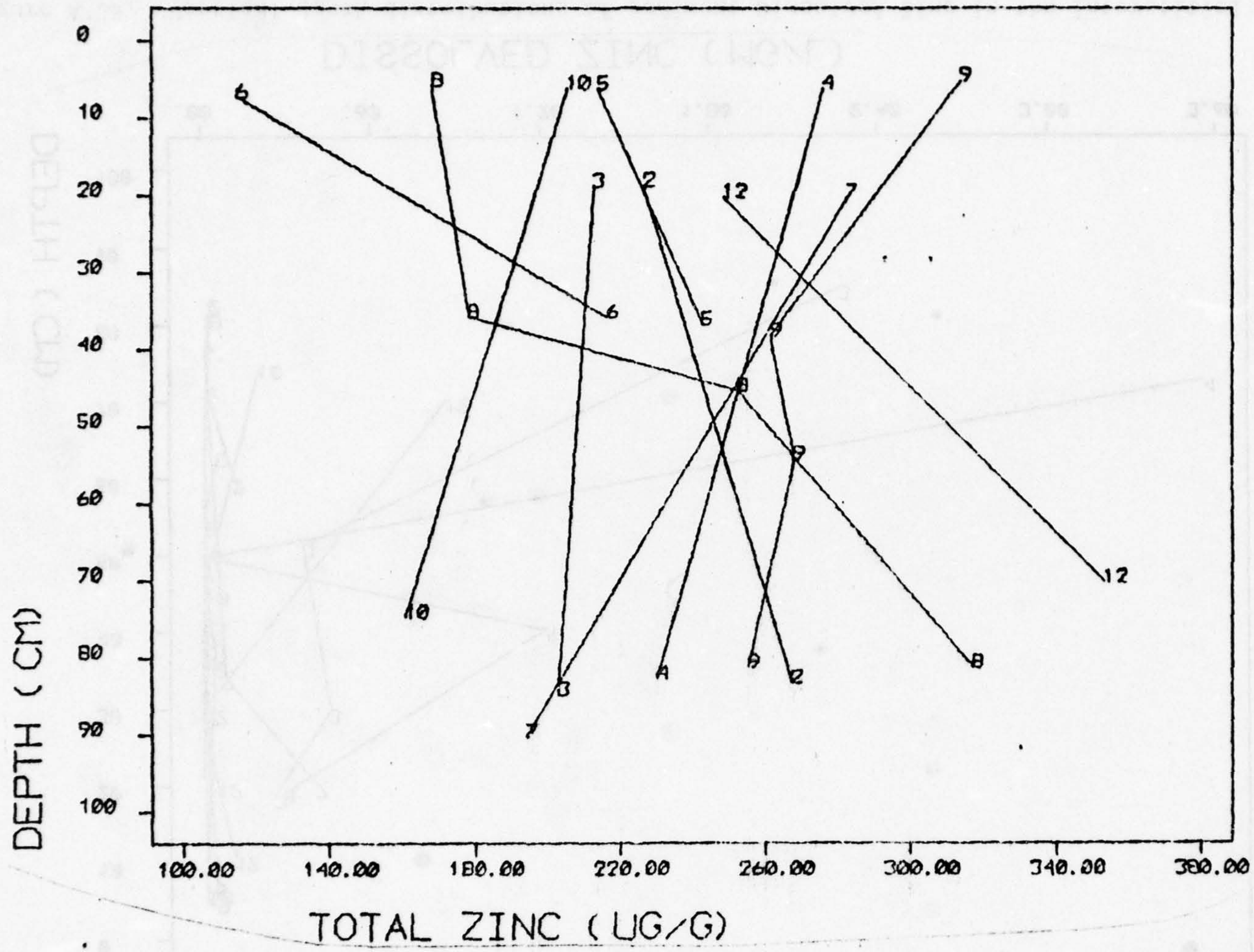

Figure A'26. Vertical depth distributions of sediment bulk Total Zinc in ten channel cores near Windmill Point, James River, Virginia, in January 1975.

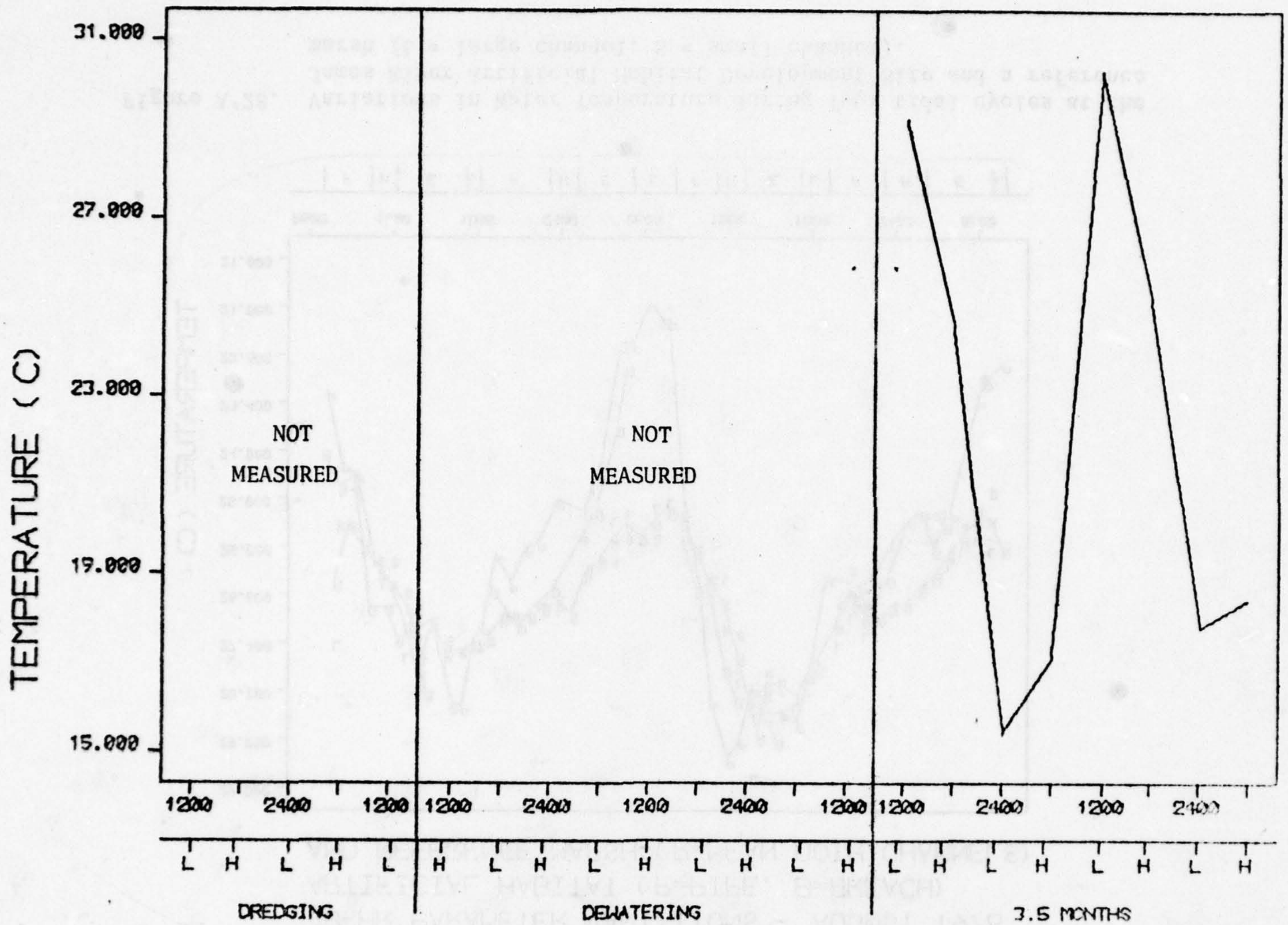

Figure A'27. Variations in Water Temperature during the 3.5 month post-dredging period at the James River intertidal diked containment area, Virginia, during May 1975.

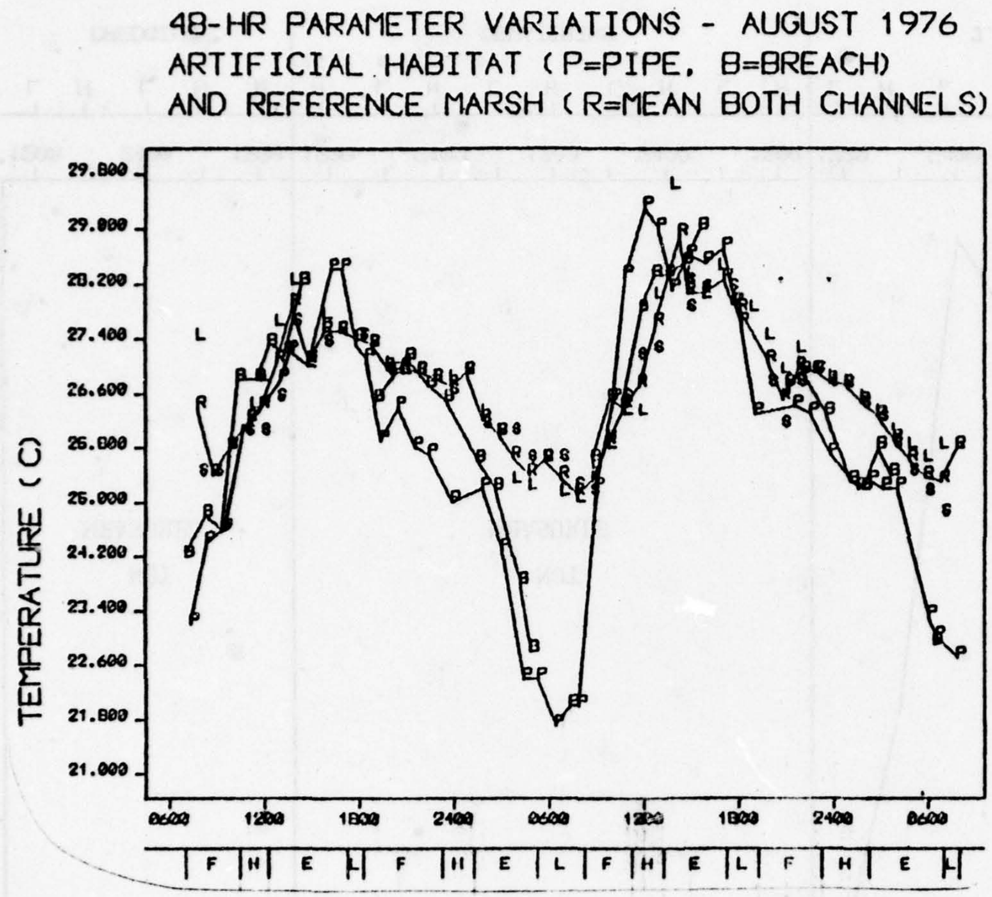

Figure A'28. Variations in Water Temperature during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (L = large channel, S = small channel).

54-HR PARAMETER VARIATIONS - JANUARY 1977
ARTIFICIAL HABITAT (P=PIPE, B=BREACH)
AND REFERENCE MARSH (R=MEAN BOTH CHANNELS)

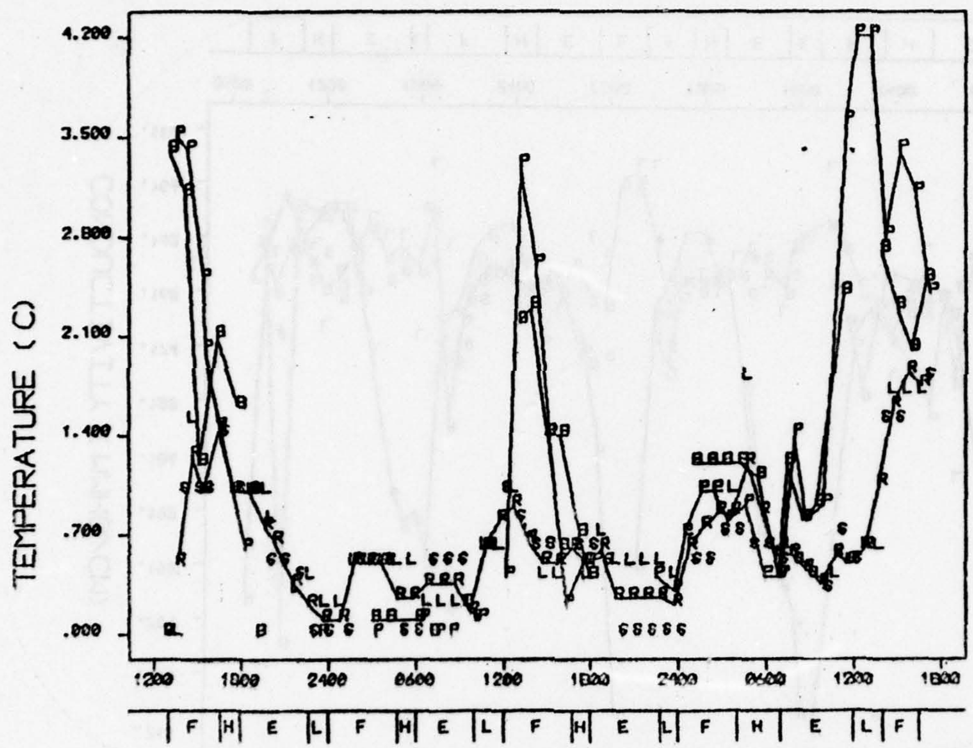

Figure A'29. Variations in Water Temperature during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (L = large channel, S = small channel).

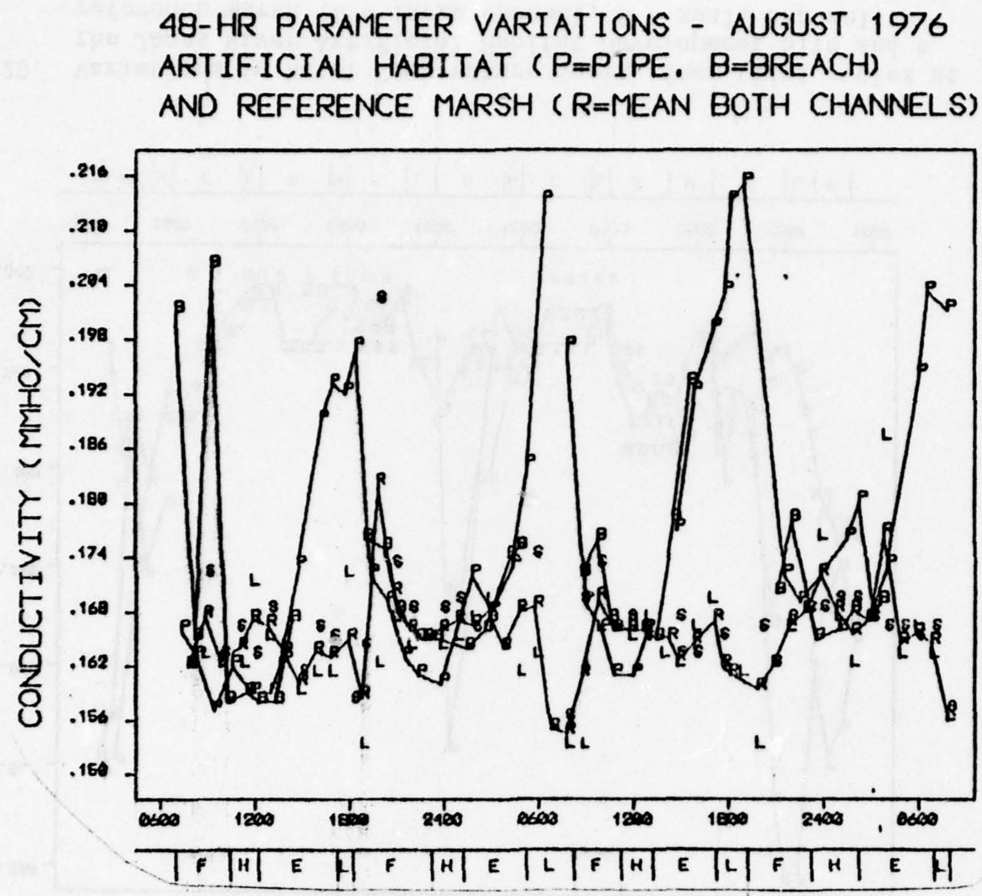

Figure A'30. Variations in Conductivity during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (L = large channel, S = small channel).

54-HR PARAMETER VARIATIONS - JANUARY 1977
ARTIFICIAL HABITAT (P=PIPE, B=BREACH)
AND REFERENCE MARSH (R=MEAN BOTH CHANNELS)

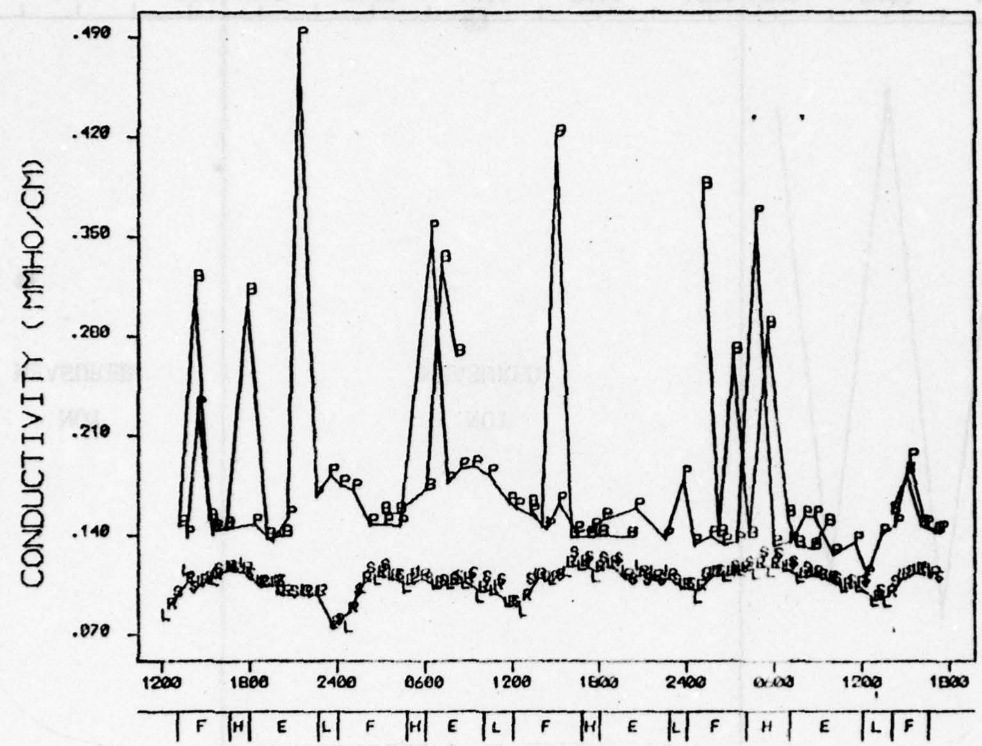

Figure A'31. Variations in Conductivity during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (L = large channel, S = small channel).

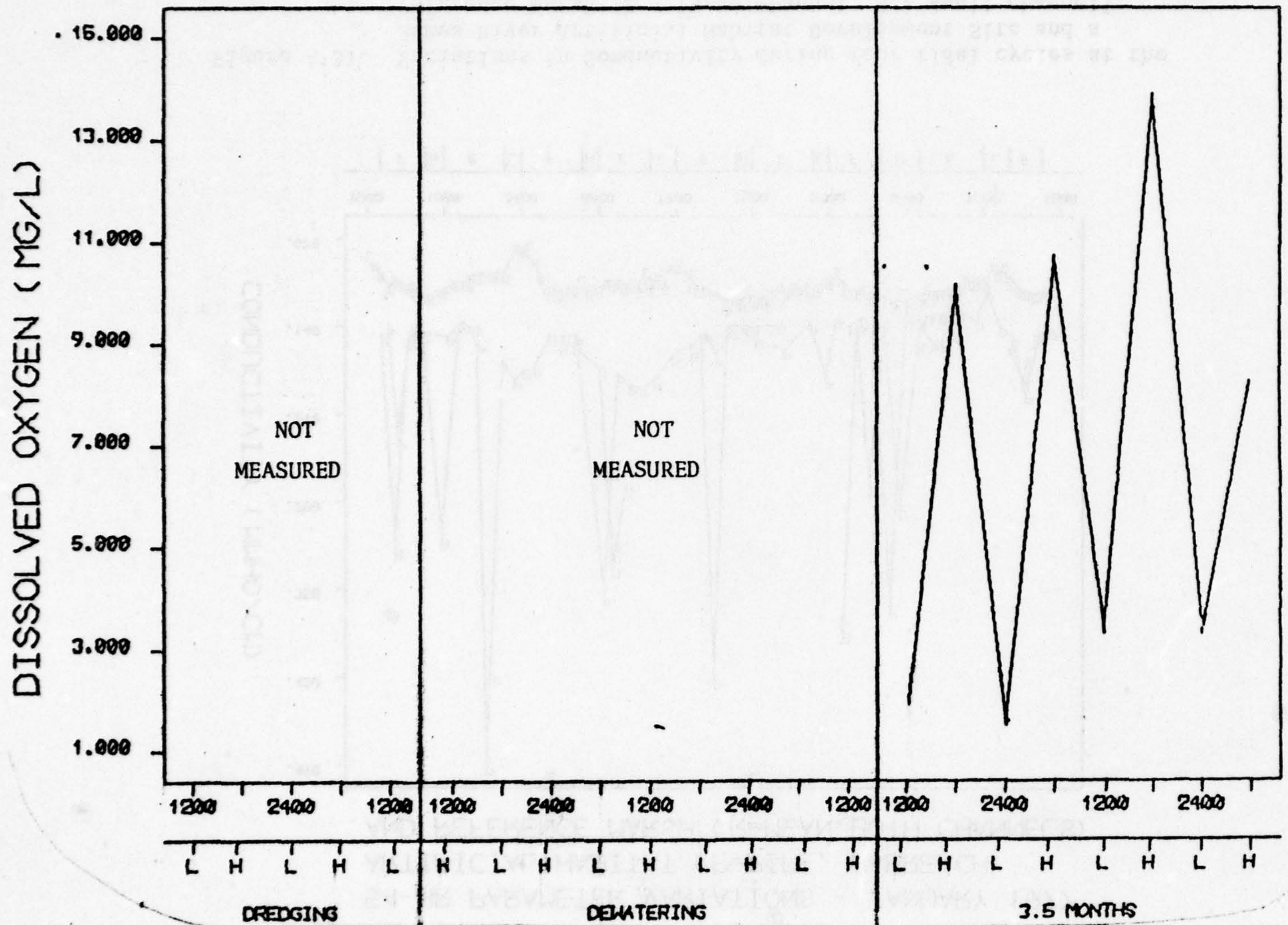

Figure A'32. Variations in Dissolved Oxygen during the 3.5 month post-dredging period at the James River intertidal diked containment area, Virginia, during May 1975.

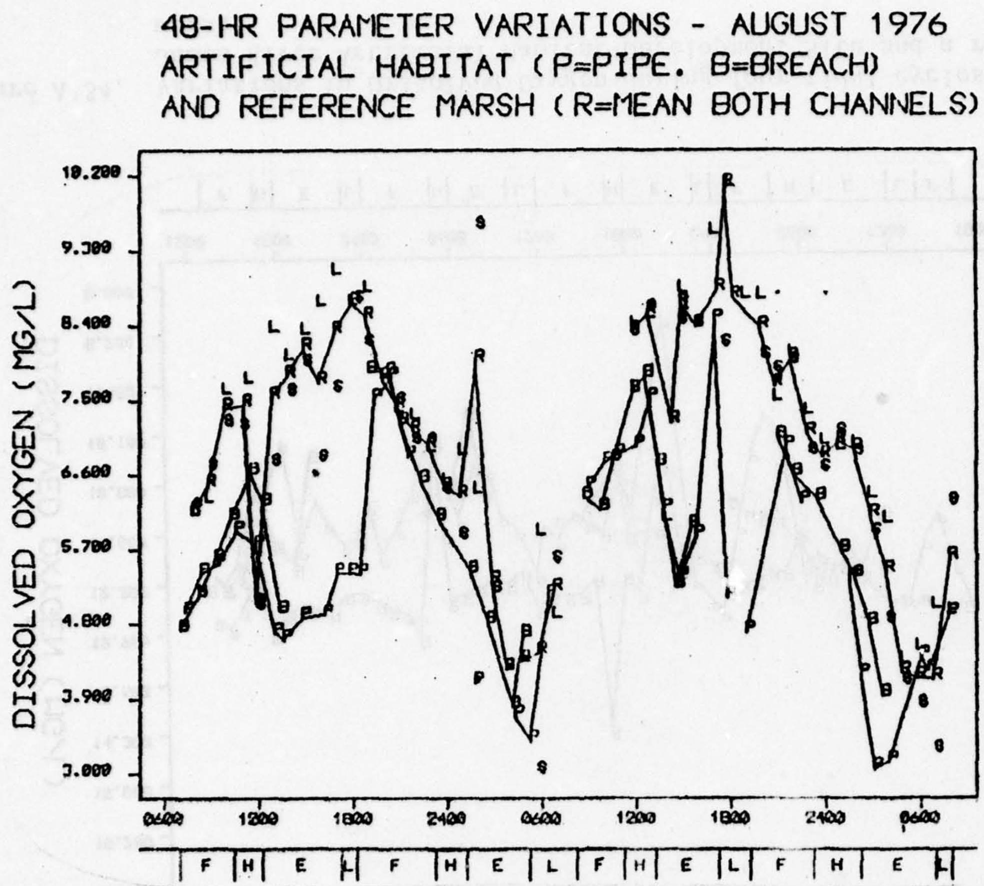

Figure A'33. Variations in Dissolved Oxygen during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (L = large channel, S = small channel).

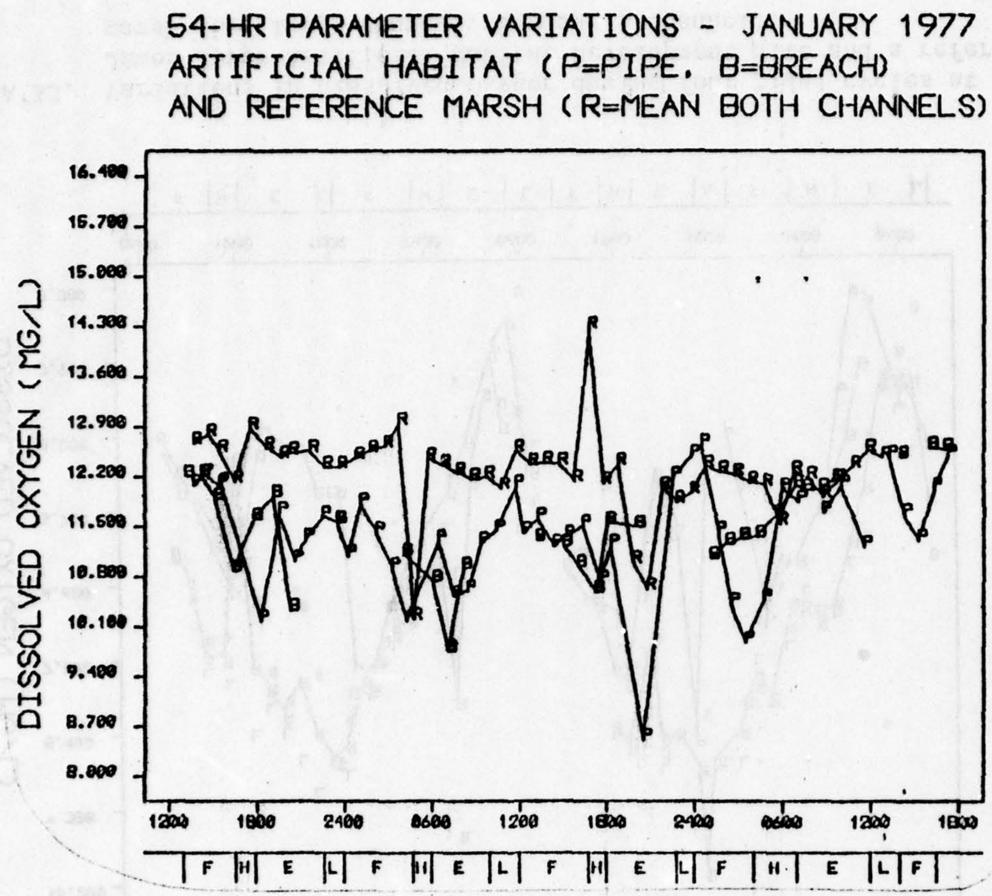

Figure A'34. Variations in Dissolved Oxygen during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh.

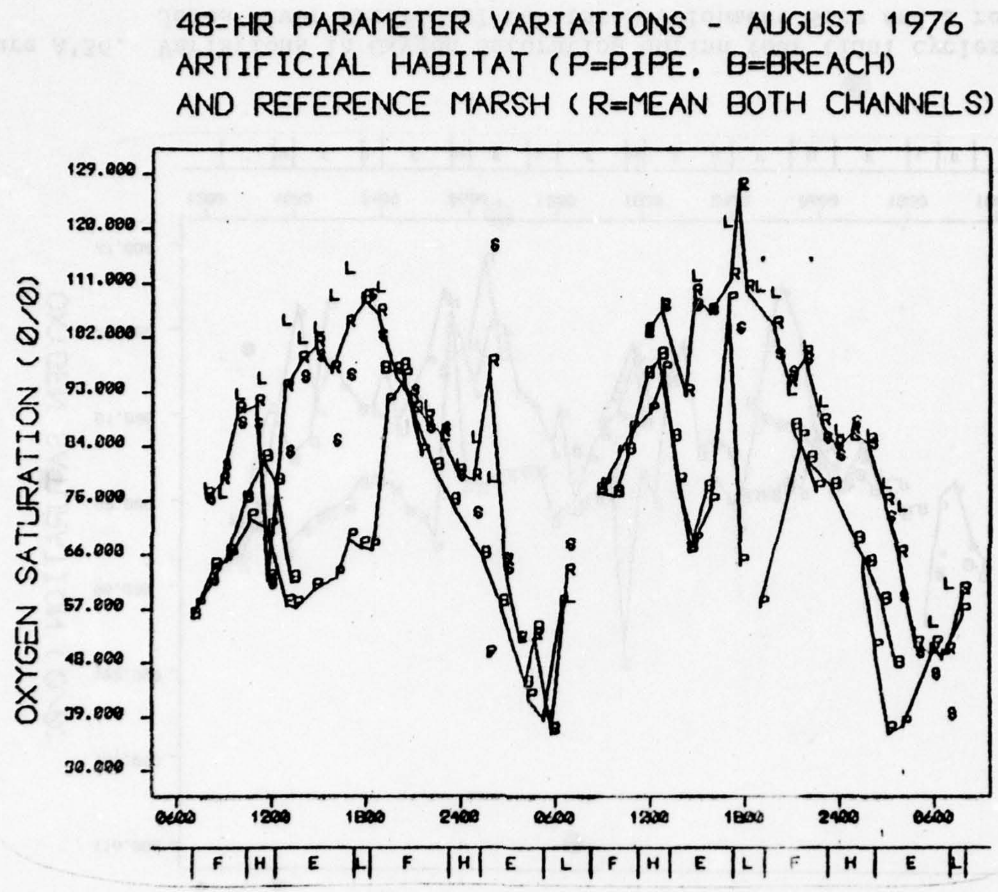

Figure A'35. Variations in Oxygen Saturation during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (L = large channel, S = small channel).

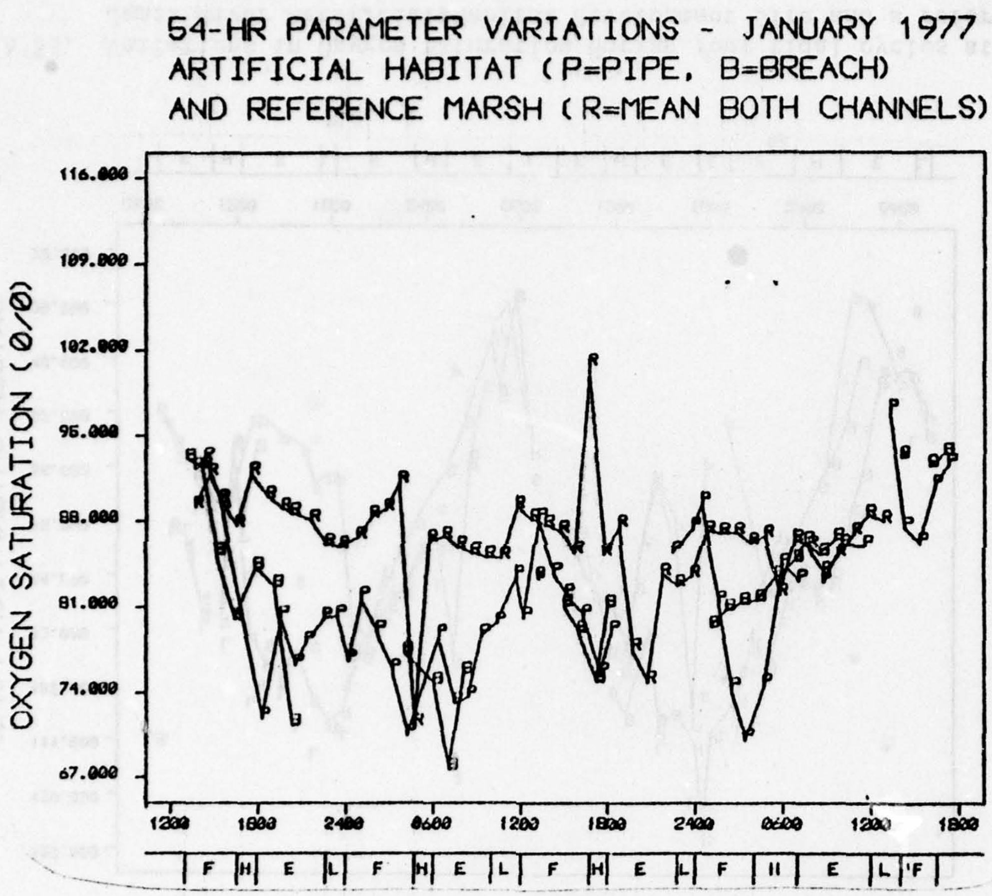

Figure A'36. Variations in Oxygen Saturation durinn four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh.

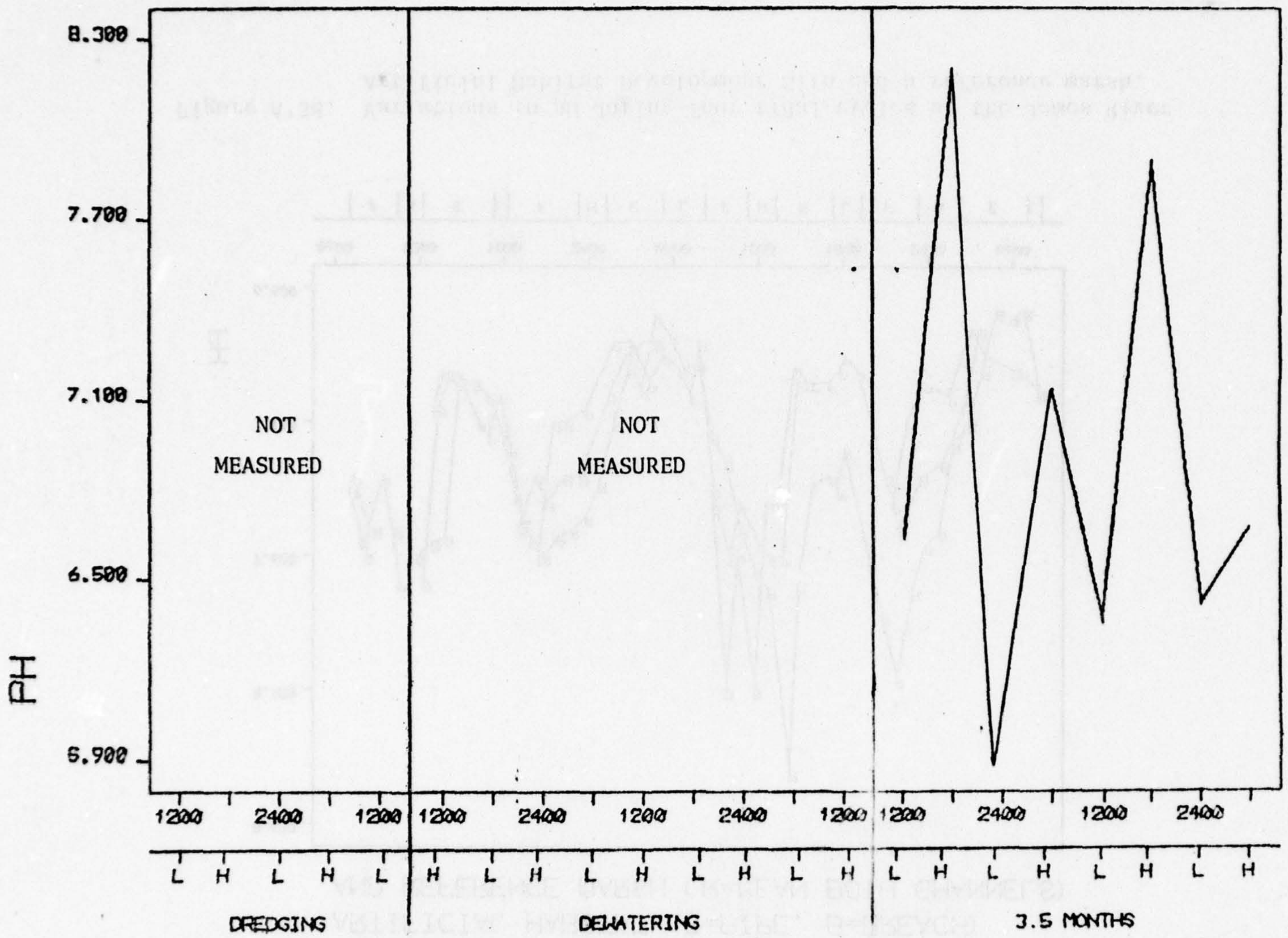

Figure A'37. Variations in pH during the 3.5 month post-dredging period at the James River intertidal diked containment area, Virginia, during May 1975.

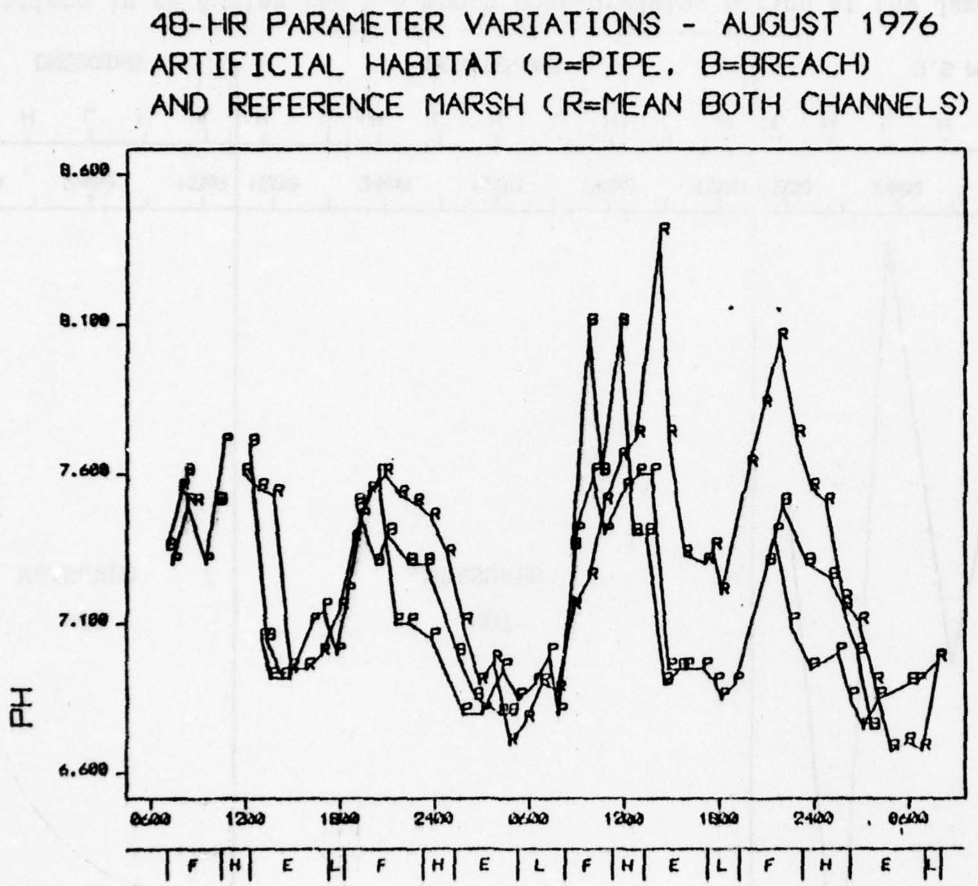

Figure A'38. Variations in pH during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh.

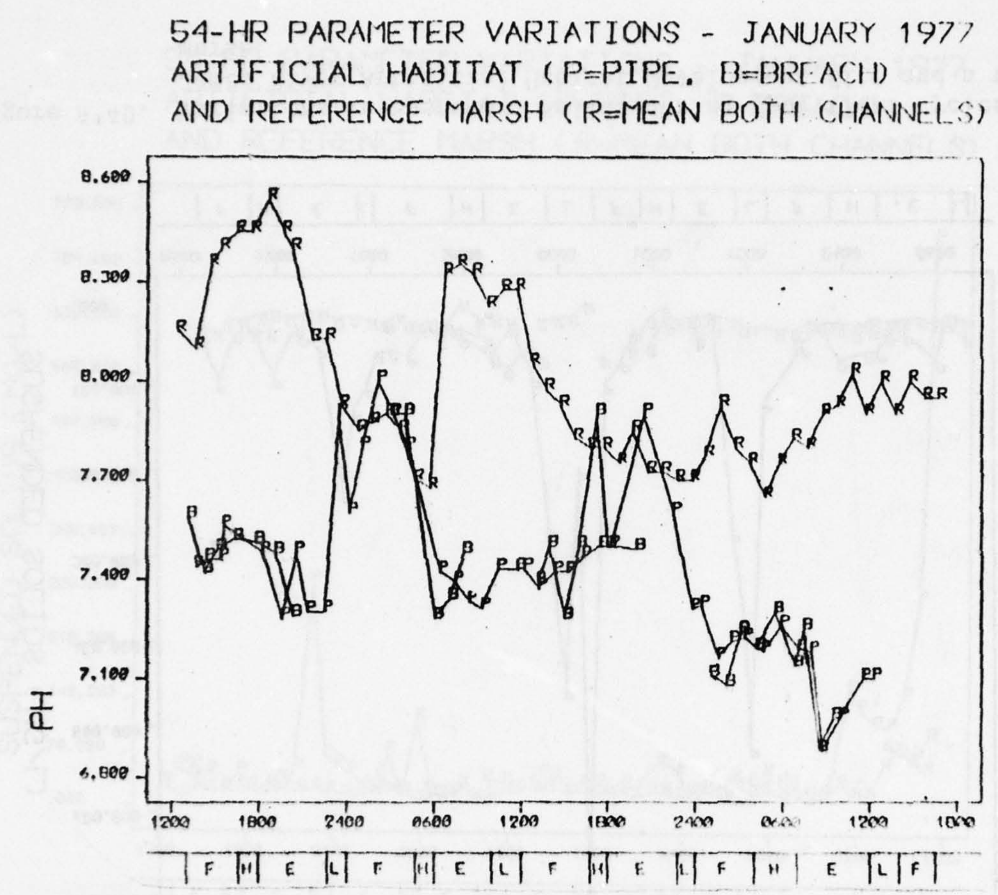

Figure A'39. Variations in pH during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh.

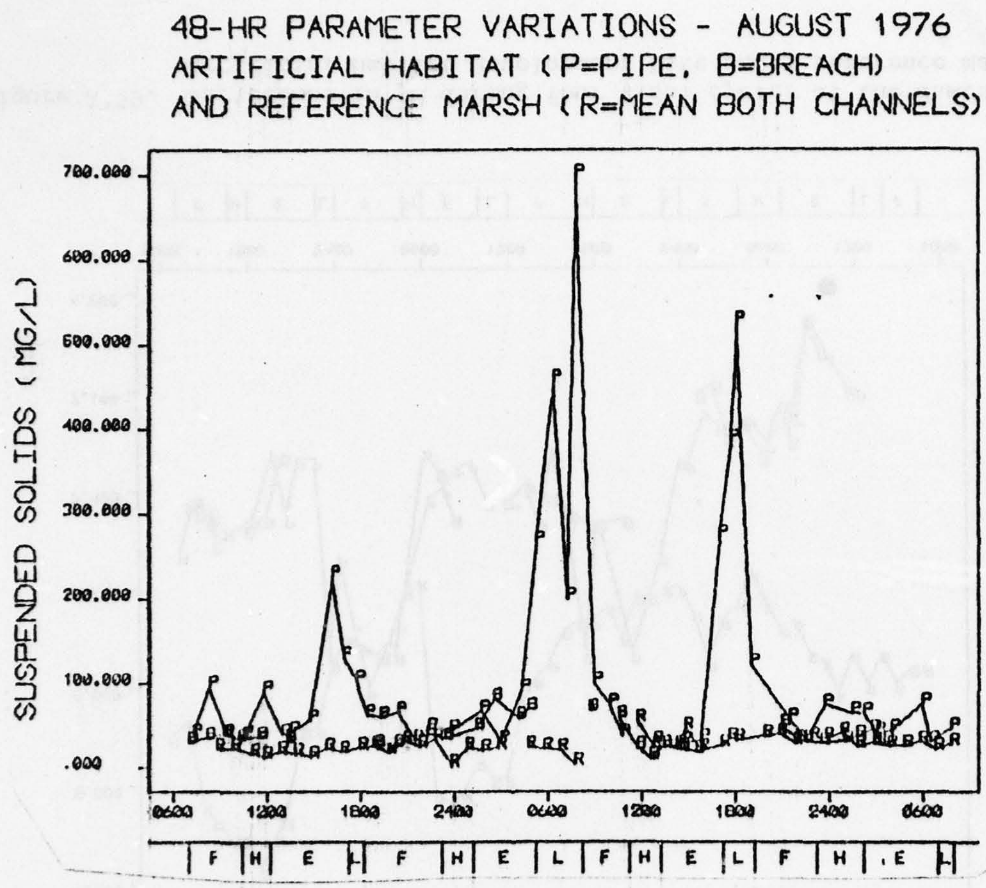

Figure A'40. Variations in Suspended Solids during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh.

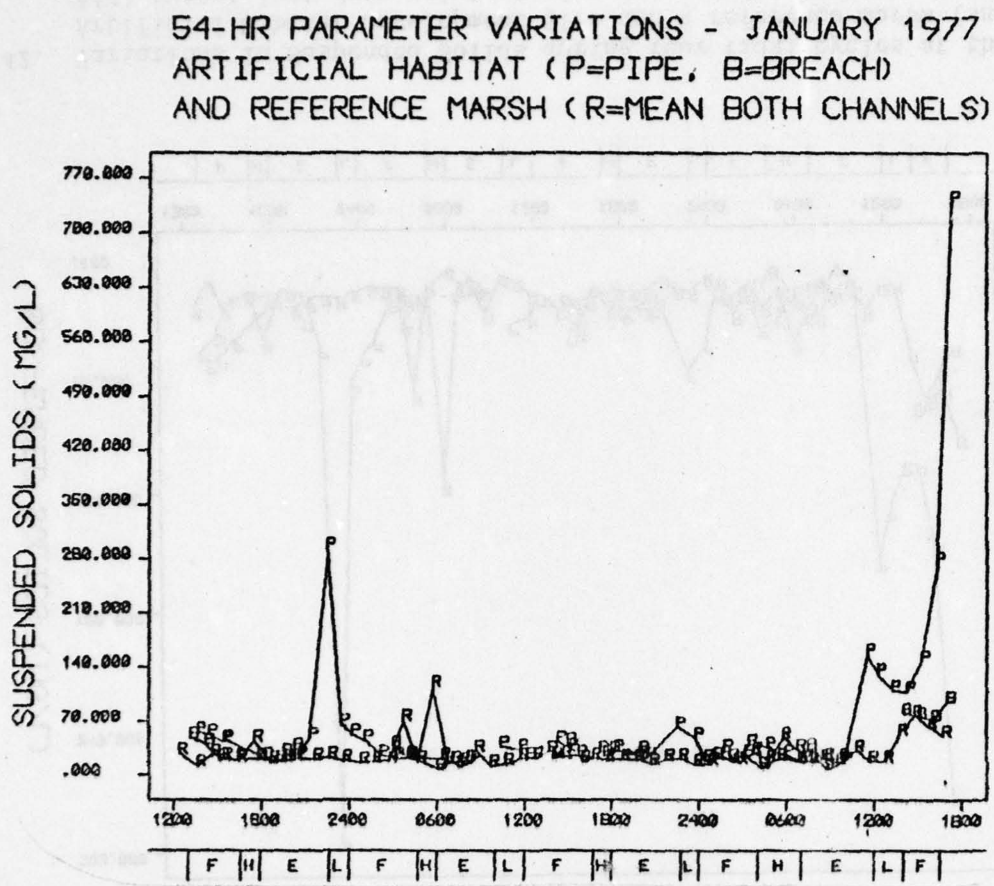

Figure A'41. Variations in Suspended Solids during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (see Figure A'42 as well).

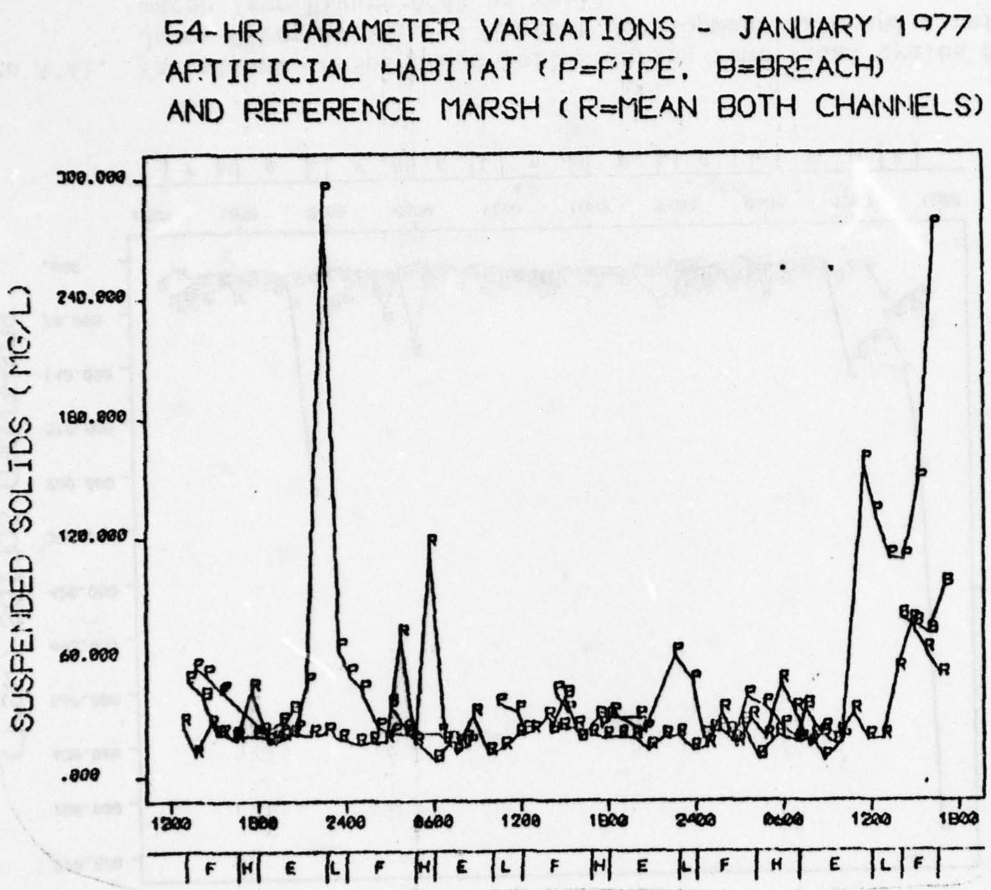

Figure A'42. Variations in Suspended Solids during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (same as Figure A'41 except last data point at pipe deleted due to high winds and wave conditions).

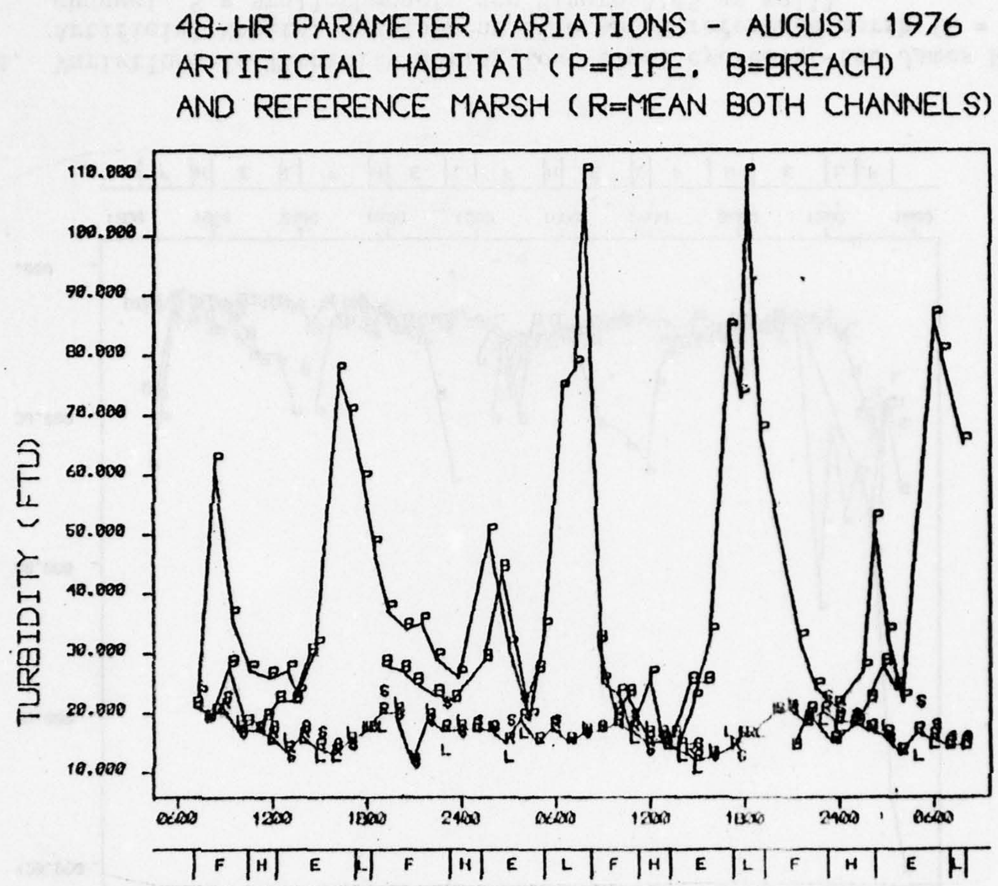

Figure A'43. Variations in Turbidity during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (L = large channel, S = small channel).

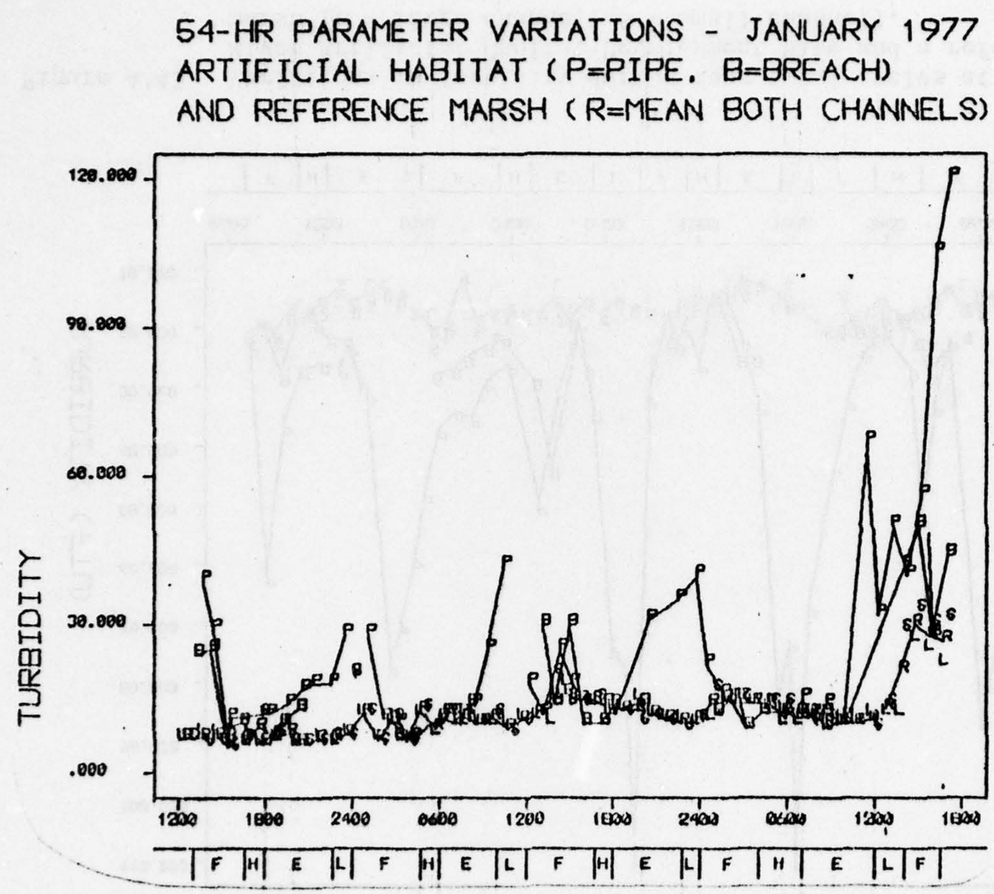

Figure A'44. Variations in Turbidity during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (L = large channel, S = small channel; see Figure A'45 as well).

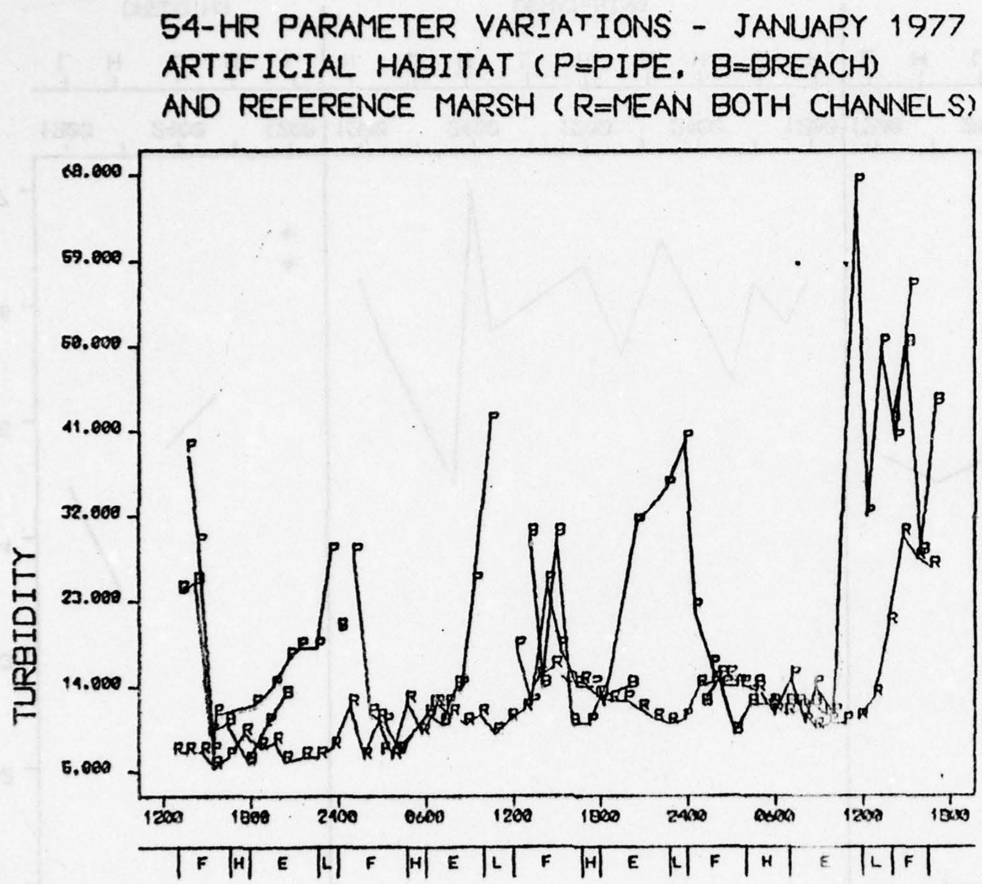

Figure A'45. Variations in Turbidity during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (same as Figure A'44 except last two data points at pipe deleted due to high winds and wave conditions).

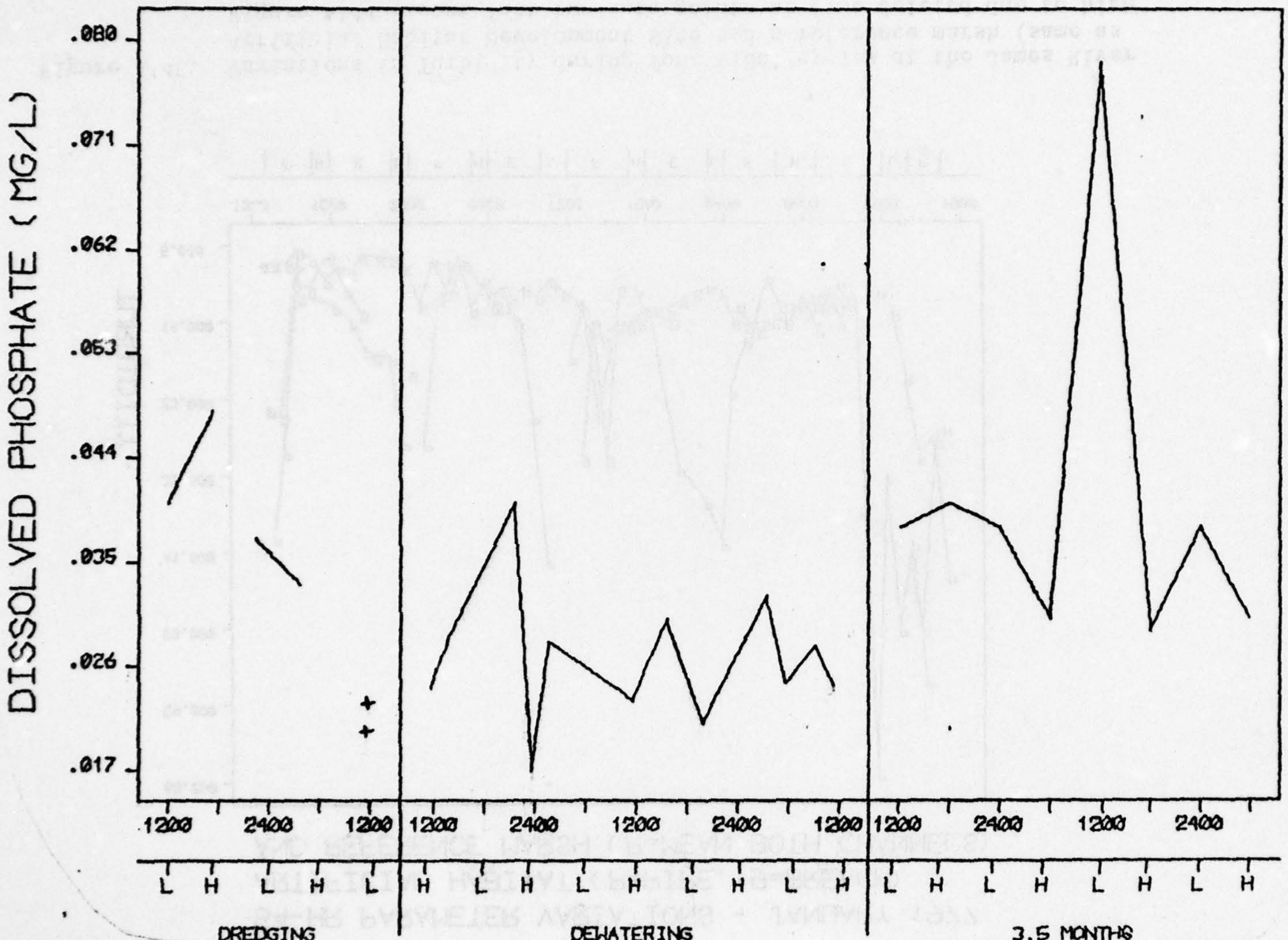

Figure A'46. Temporal changes in Dissolved Orthophosphate during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, during Jan-May 1975 (+ = samples collected 15 minutes apart).

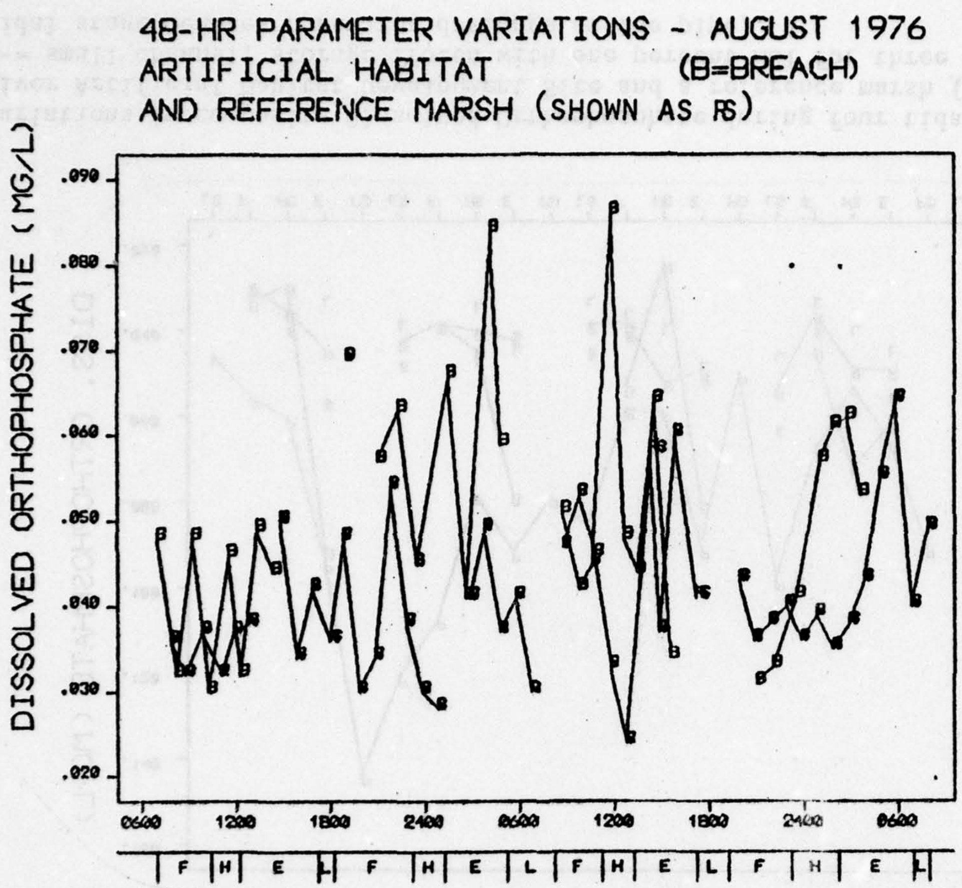

Figure A'47. Variations in Dissolved Orthophosphate during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (analyzed hourly for ABα and RSα samples only).

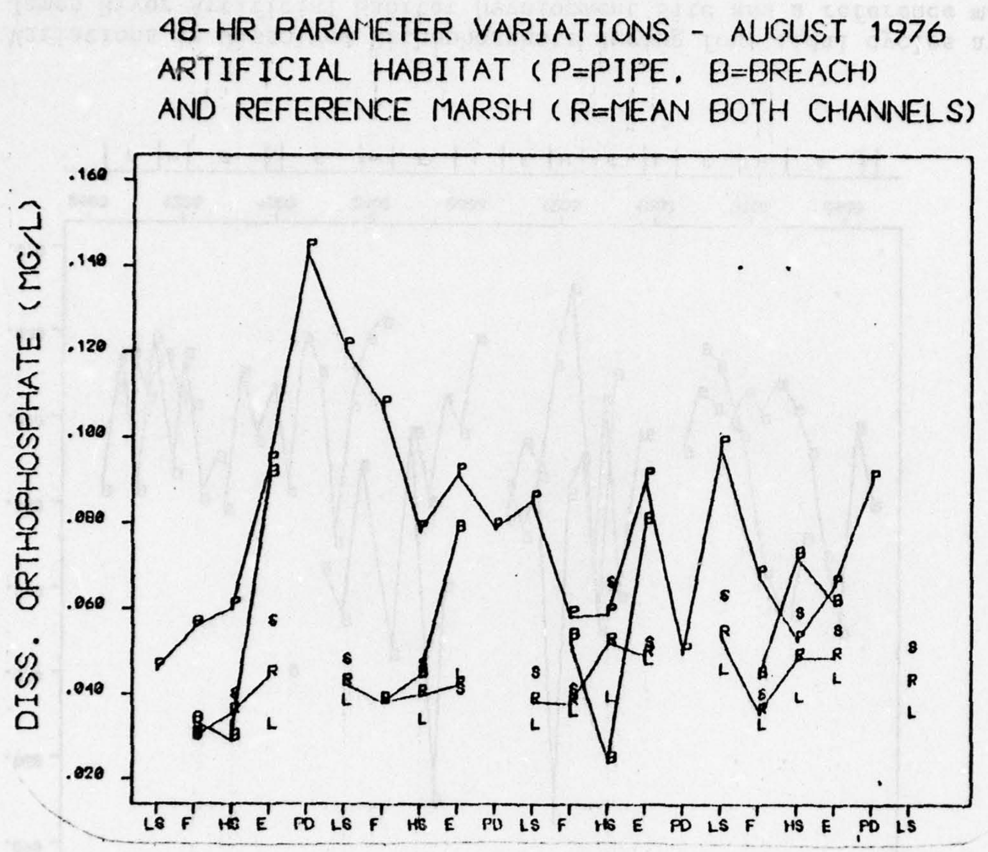

Figure A'48. Variations in composite Dissolved Orthophosphate during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (L = large channel, S = small channel; storage frozen with one percent HCl for three to five months; PD tidal stage denotes porewater drainage at the pipe).

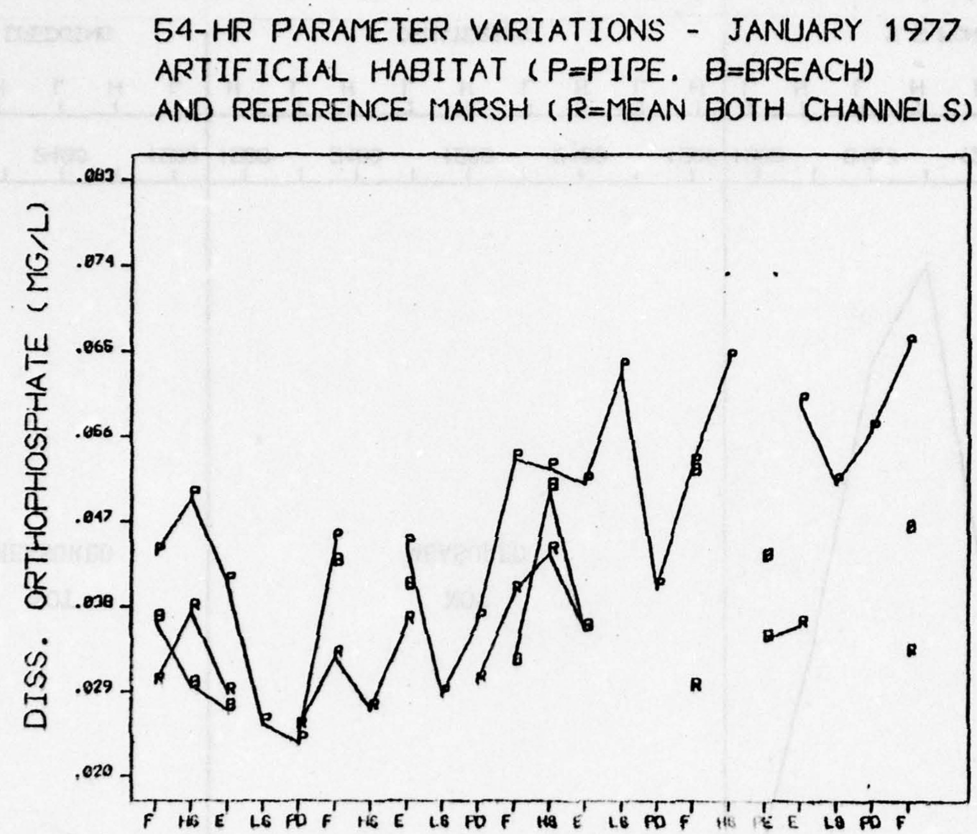

Figure A'49. Variations in composite Dissolved Orthophosphate during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (PD tidal stage denotes porewater drainage at the pipe).

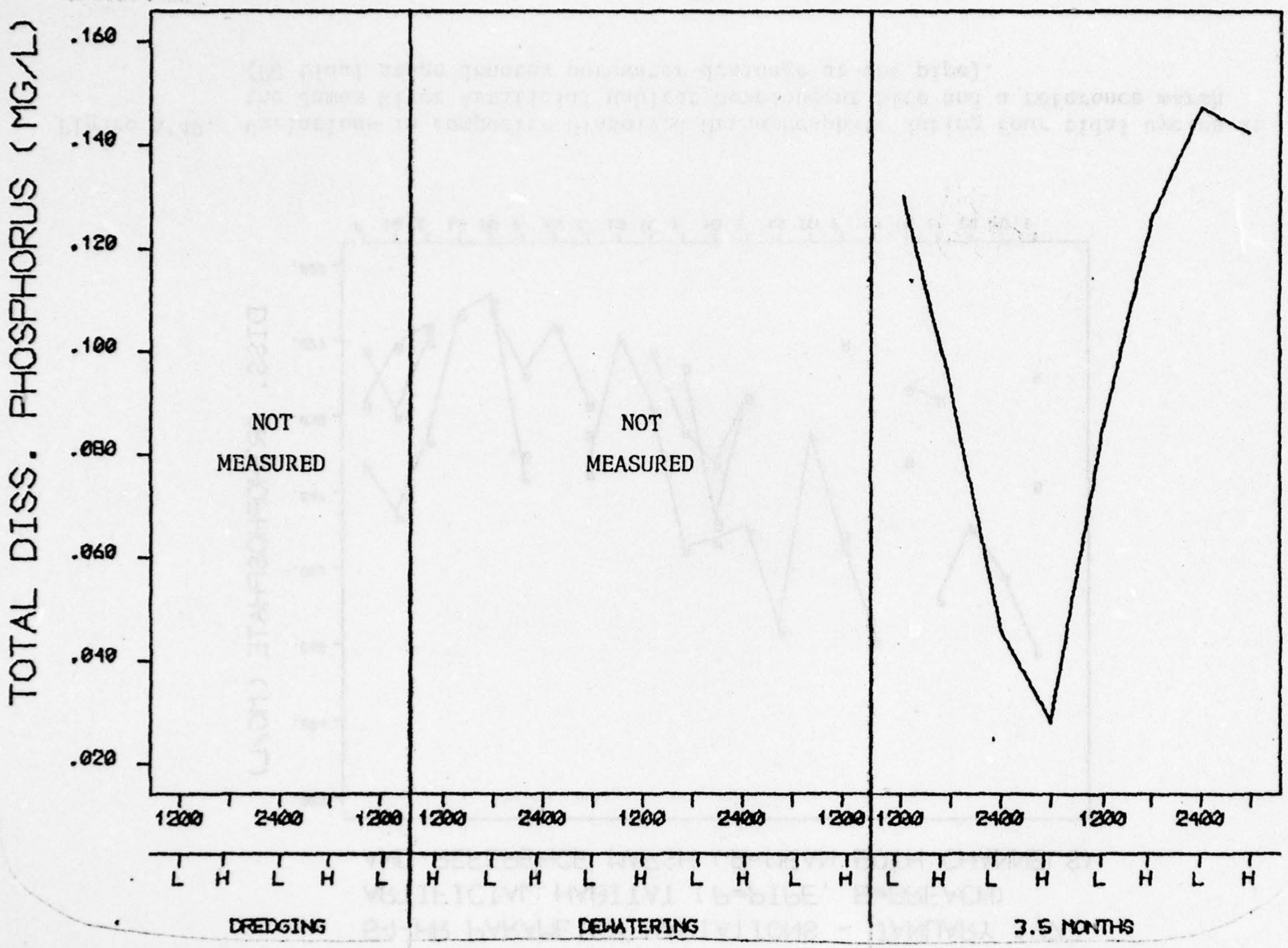

Figure A'50. Variations in Total Dissolved Phosphorus during the 3.5 month post-dredging period at the James River intertidal diked containment area, Virginia, during May 1975.

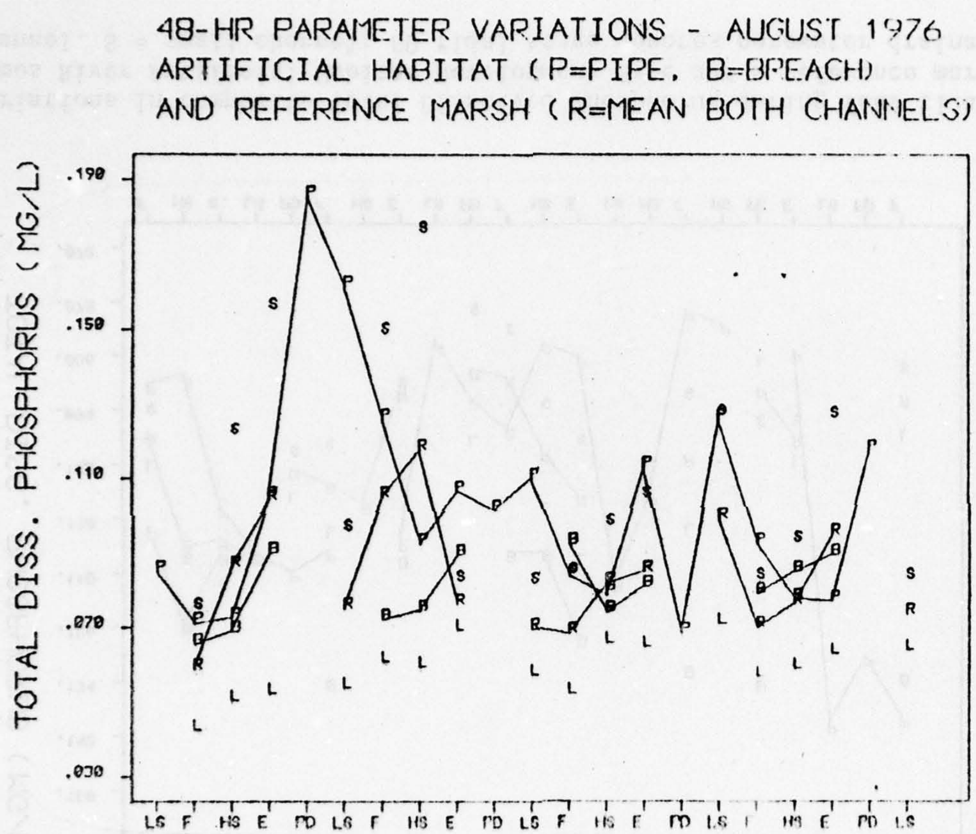

Figure A'51. Variations in composite Total Dissolved Phosphorus during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (L = large channel, S = small channel; PD tidal stage denotes porewater drainage at the pipe).

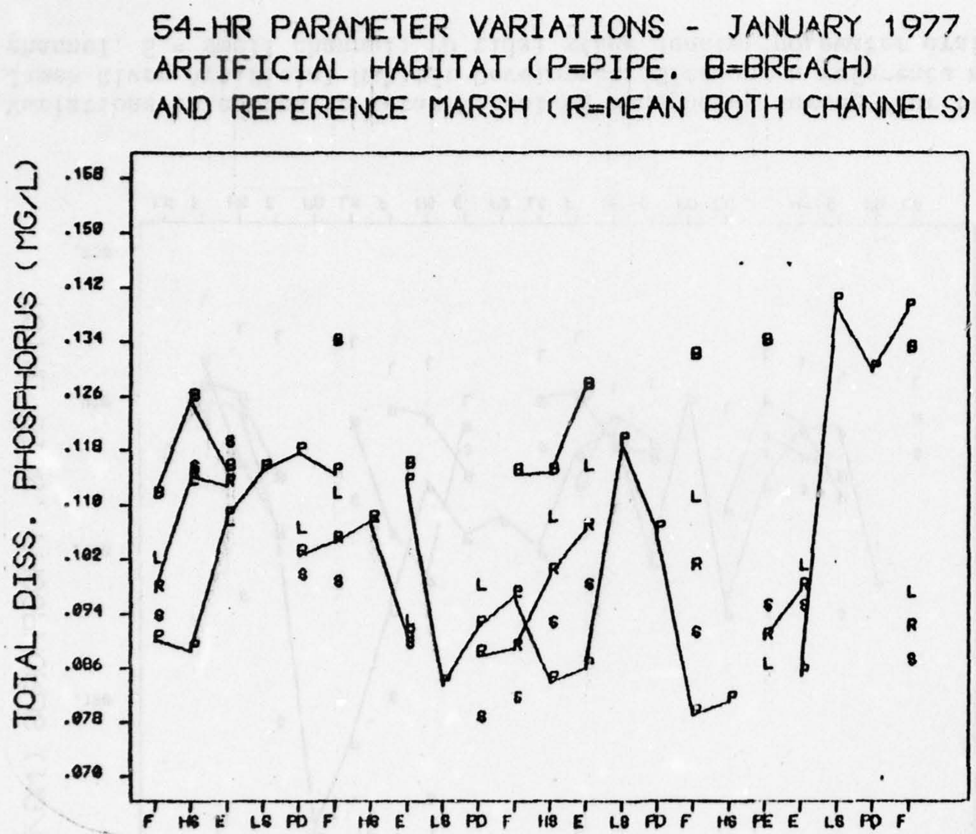

Figure A'52. Variations in composite Total Dissolved Phosphorus during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (L = large channel, S = small channel; PD tidal stage denotes porewater drainage at the pipe).

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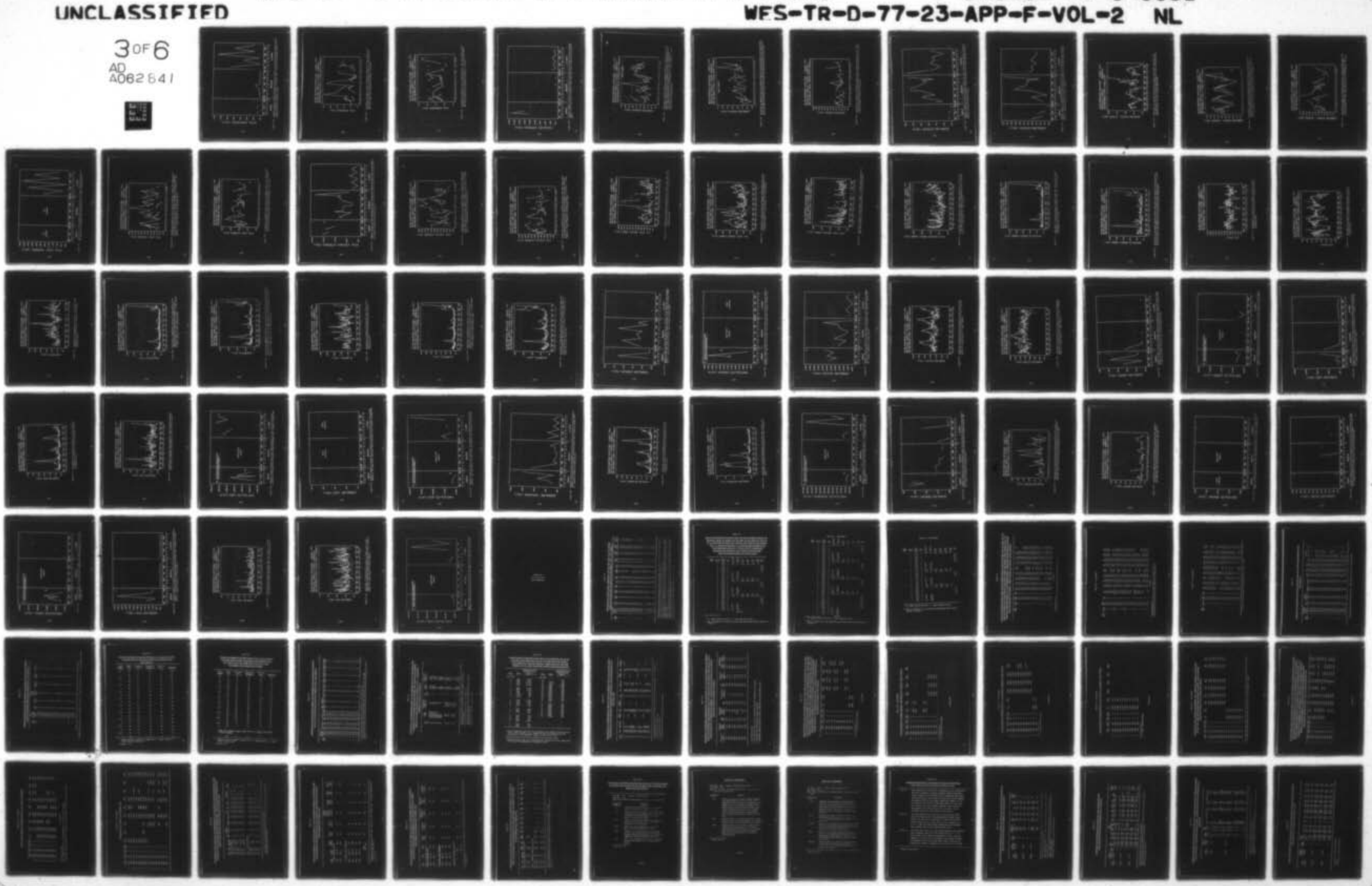

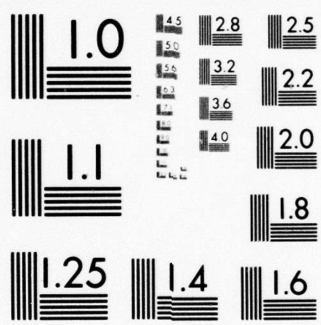

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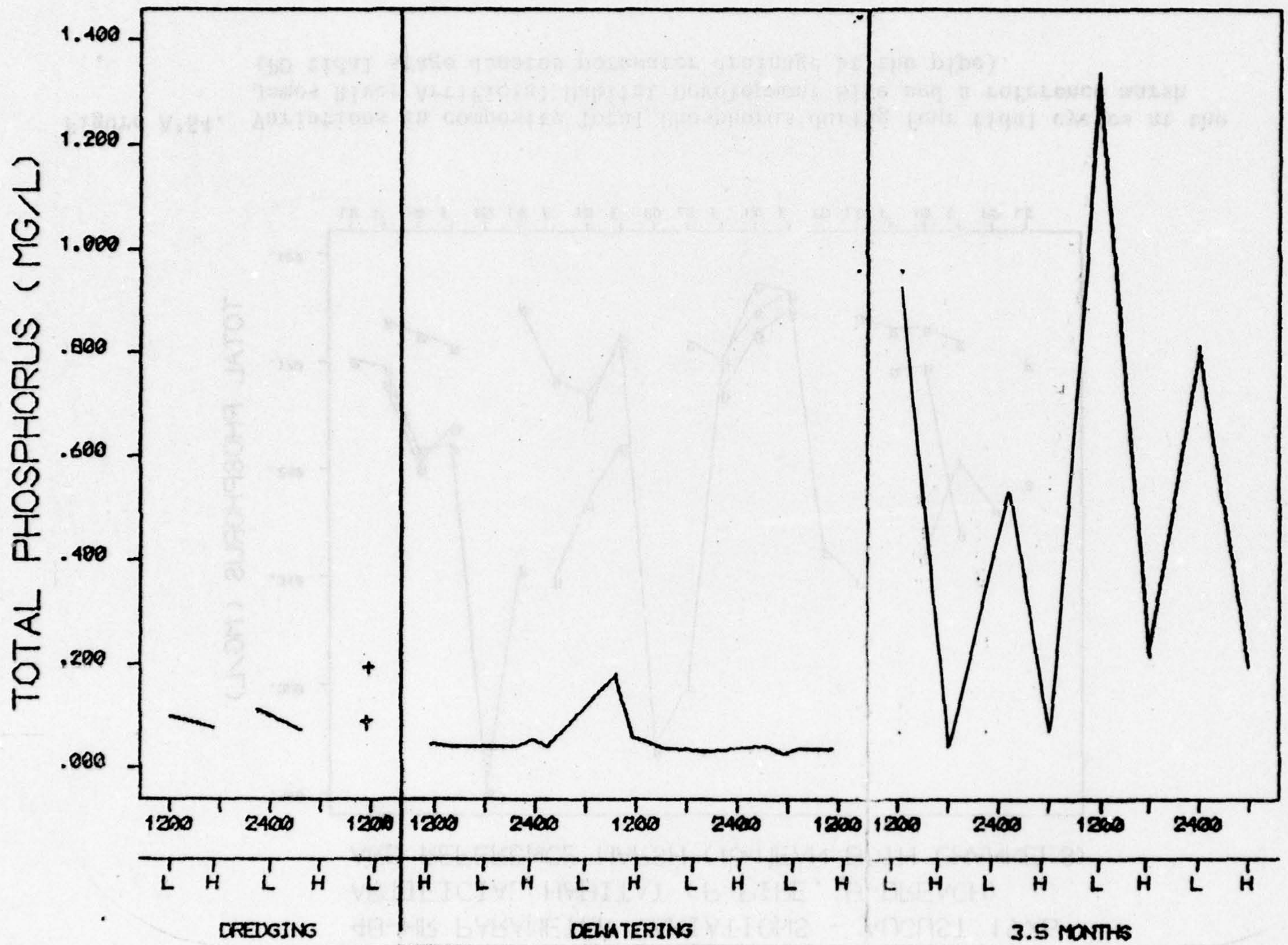

Figure A'53. Temporal changes in Total Phosphorus during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, during Jan-May 1975 (+ = samples collected 15 minutes apart).

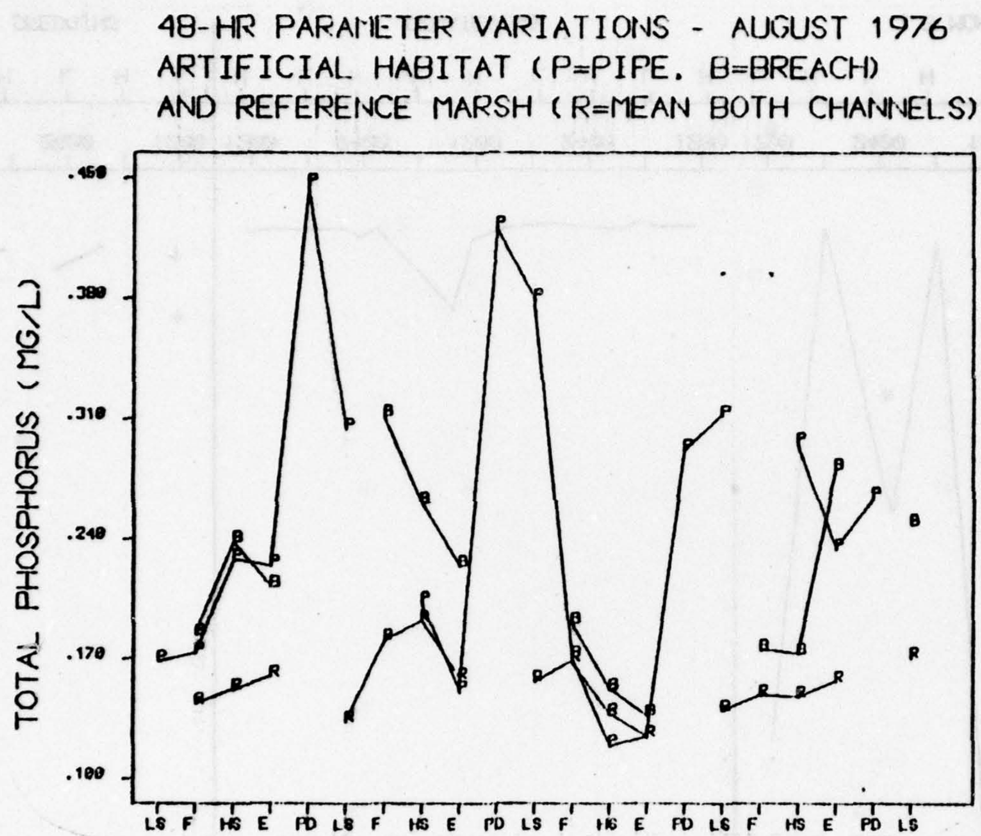

Figure A'54. Variations in composite Total Phosphorus during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (PD tidal stage denotes porewater drainage at the pipe).

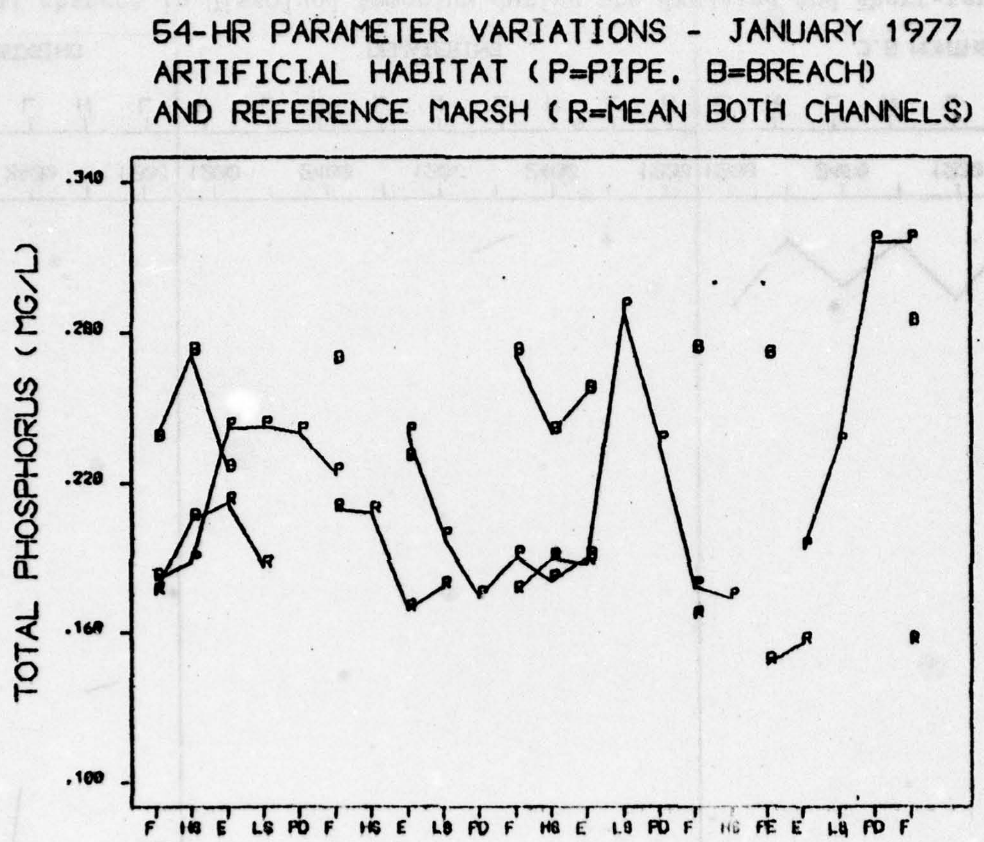

Figure A'55. Variations in composite Total Phosphorus during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (PD tidal stage denotes porewater drainage at the pipe).

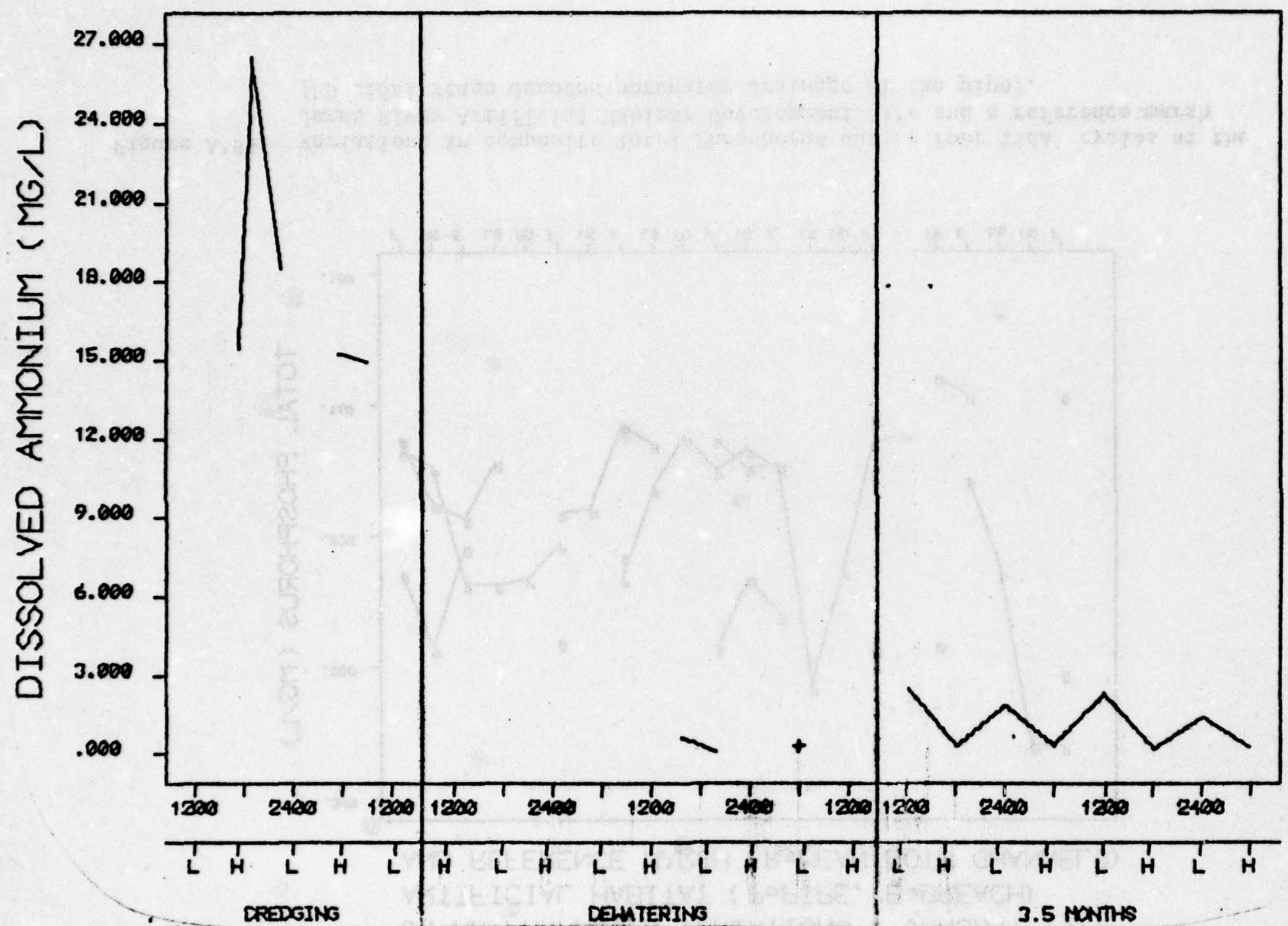

Figure A'56. Temporal changes in Dissolved Ammonium during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, during Jan-May 1975.

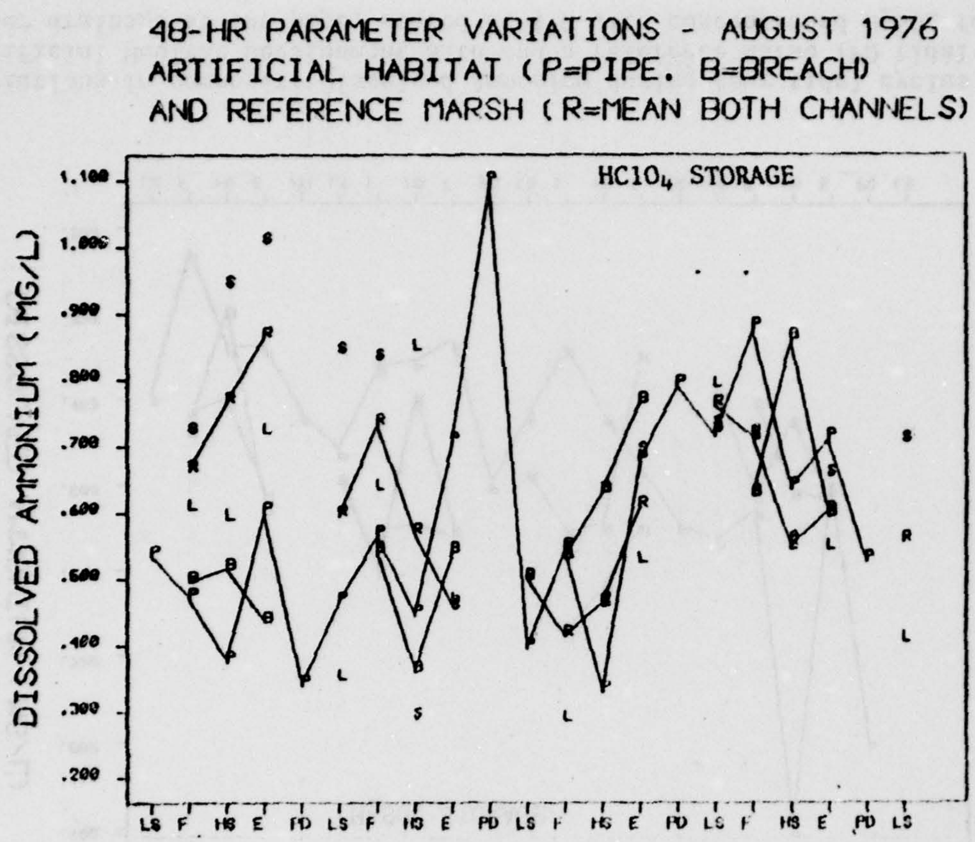

Figure A'57. Variations in composite Dissolved Ammonium during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (PD tidal stage denotes porewater drainage at pipe; stored frozen with concentrated perchloric acid for six weeks; L = large channel, S = small channel at the reference marsh).

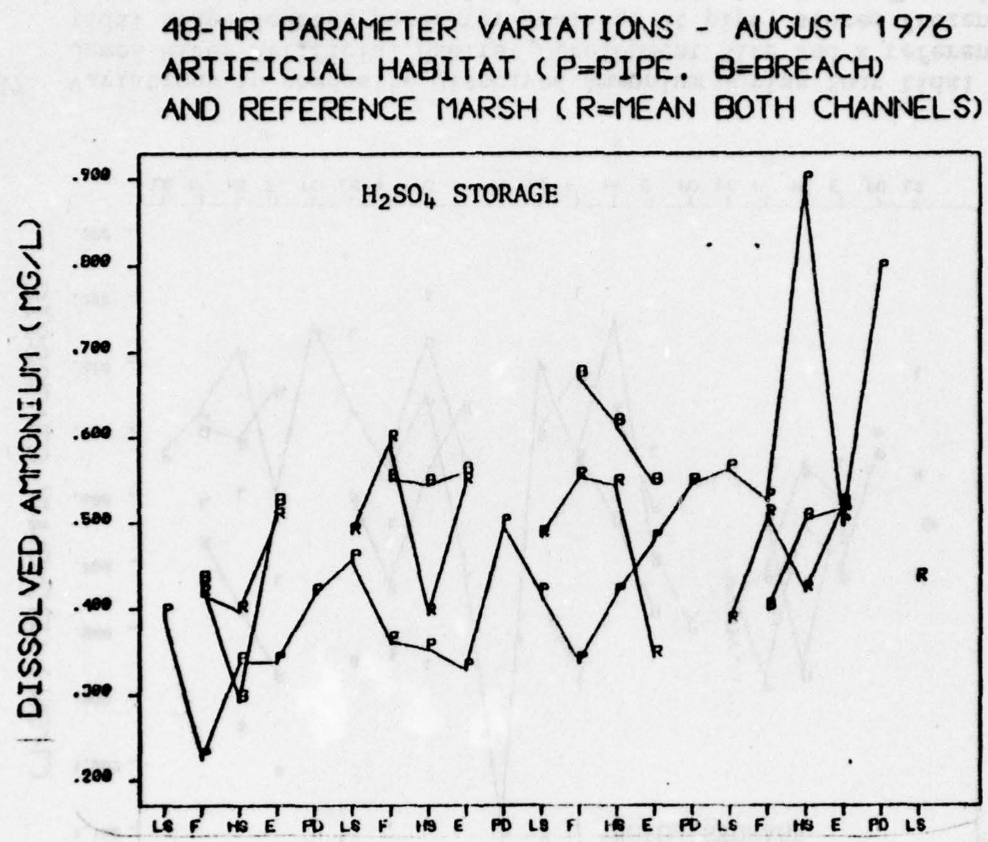

Figure A'58. Variations in composite Dissolved Ammonium during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (PD tidal stage denotes pore-water drainage at the pipe; stored at 4°C with concentrated H_2SO_4 for seven days).

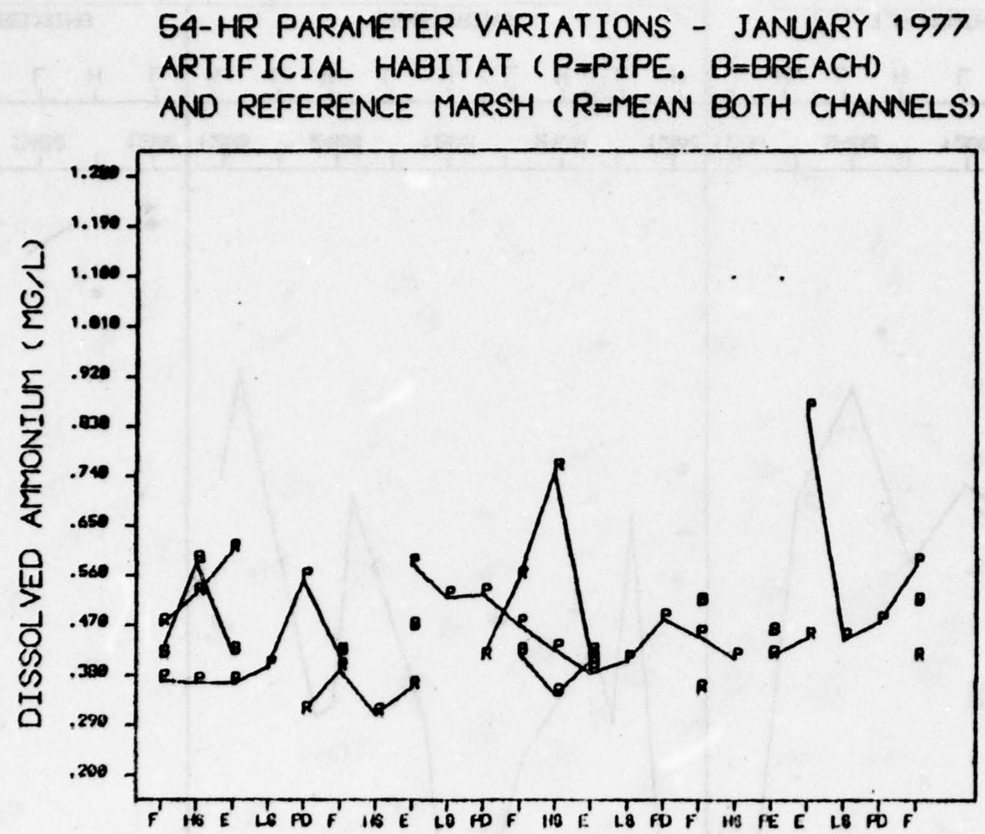

Figure A'59. Variations in composite Dissolved Ammonium during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (PD tidal stage denotes porewater drainage at the pipe).

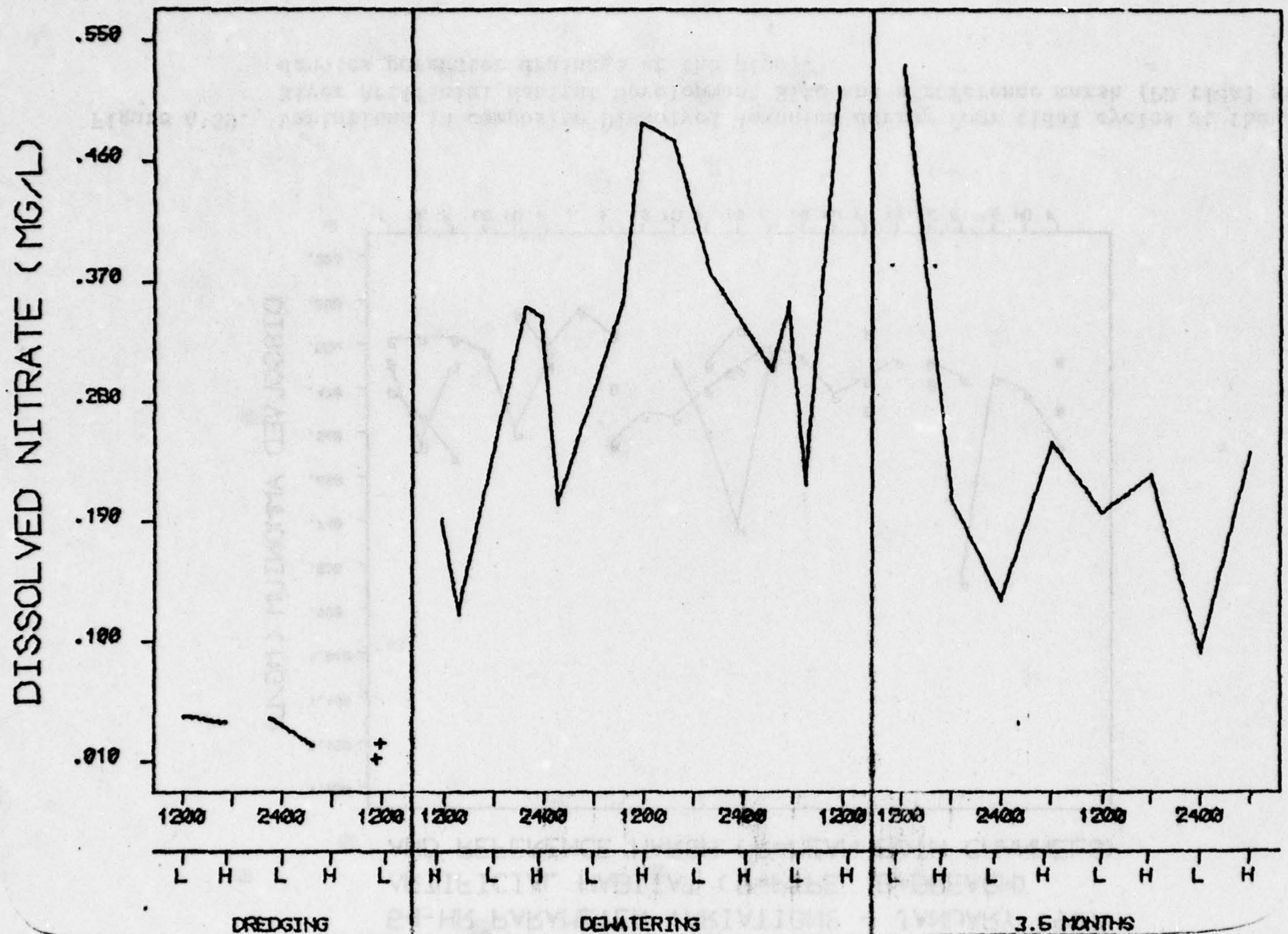

Figure A'60. Temporal changes in Dissolved Nitrate during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, during Jan-May 1975 (+ = samples collected 15 minutes apart)

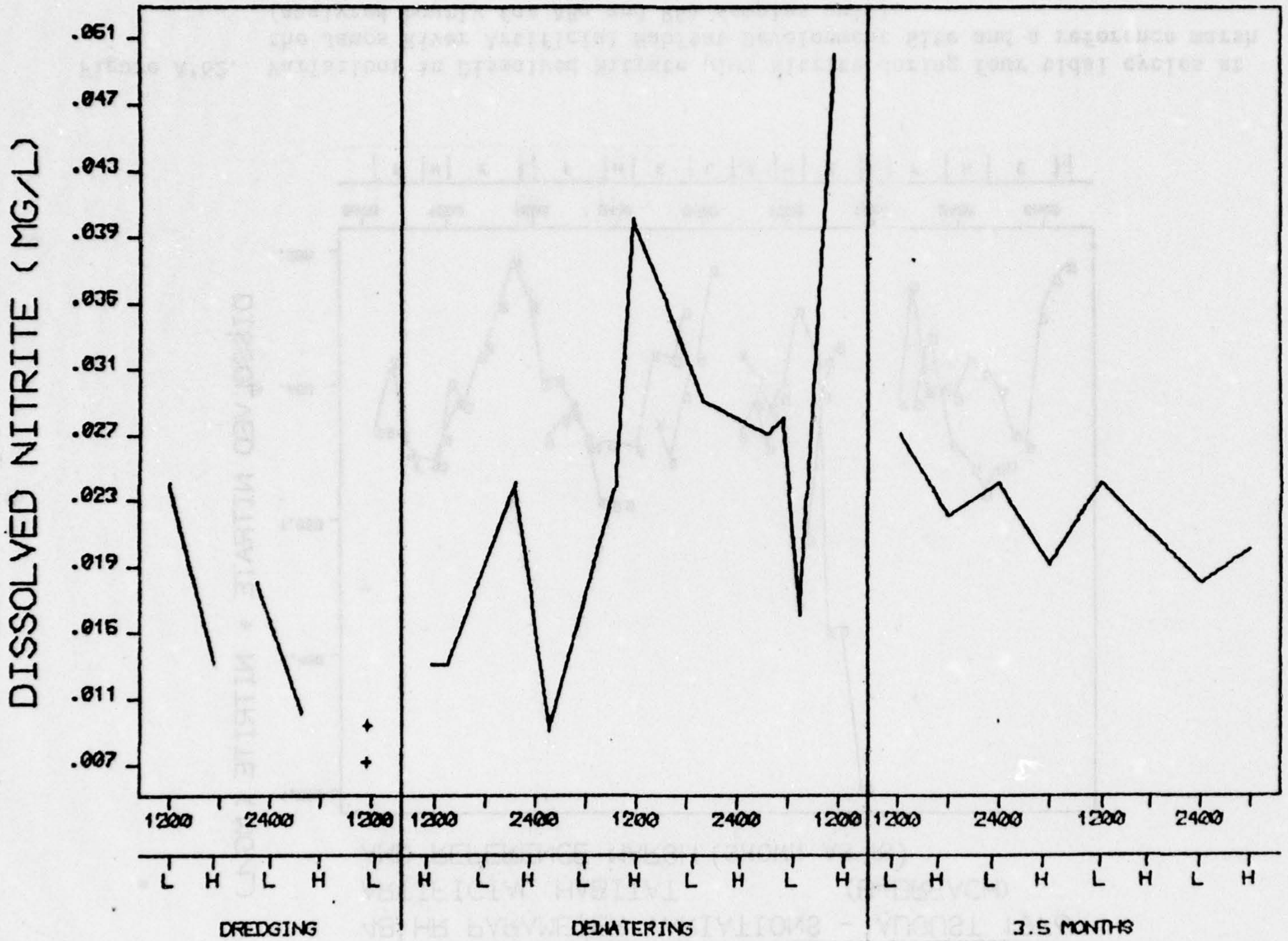

Figure A'61. Temporal changes in Dissolved Nitrite during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, during Jan-May 1975 (+ = samples collected 15 minutes apart).

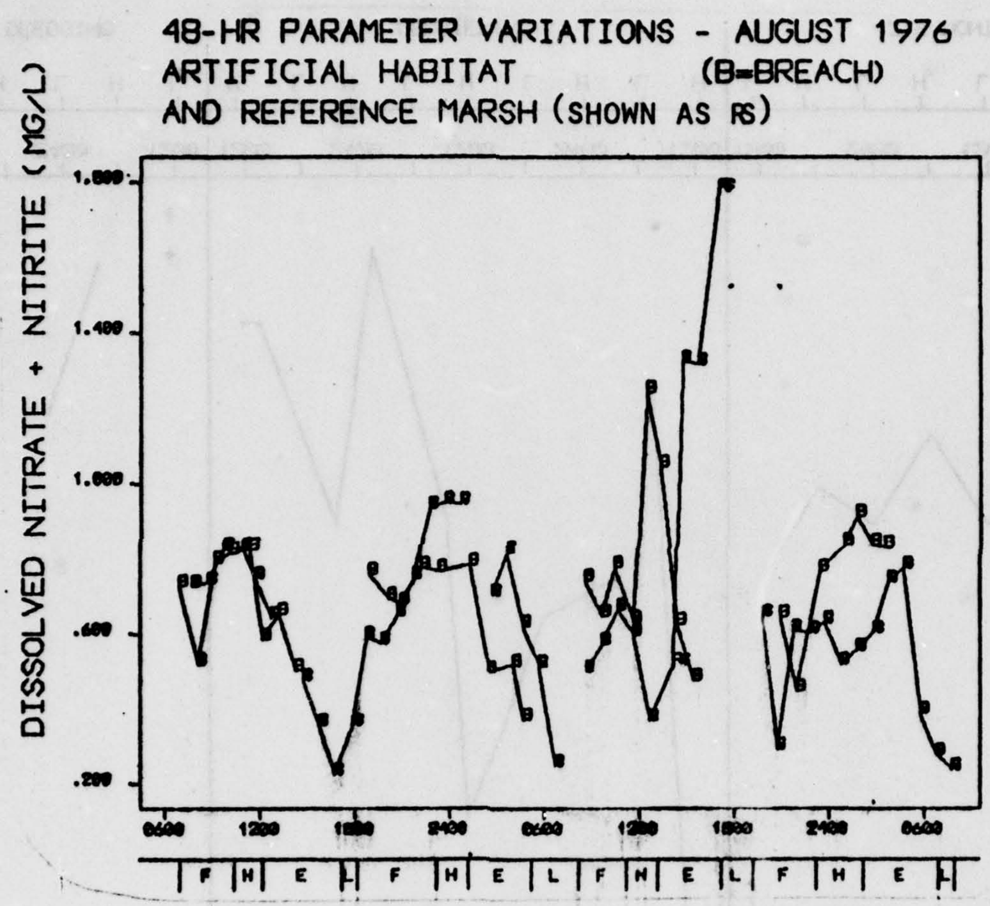

Figure A'62. Variations in Dissolved Nitrate plus Nitrite during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (analyzed hourly for ABα and RSα samples only).

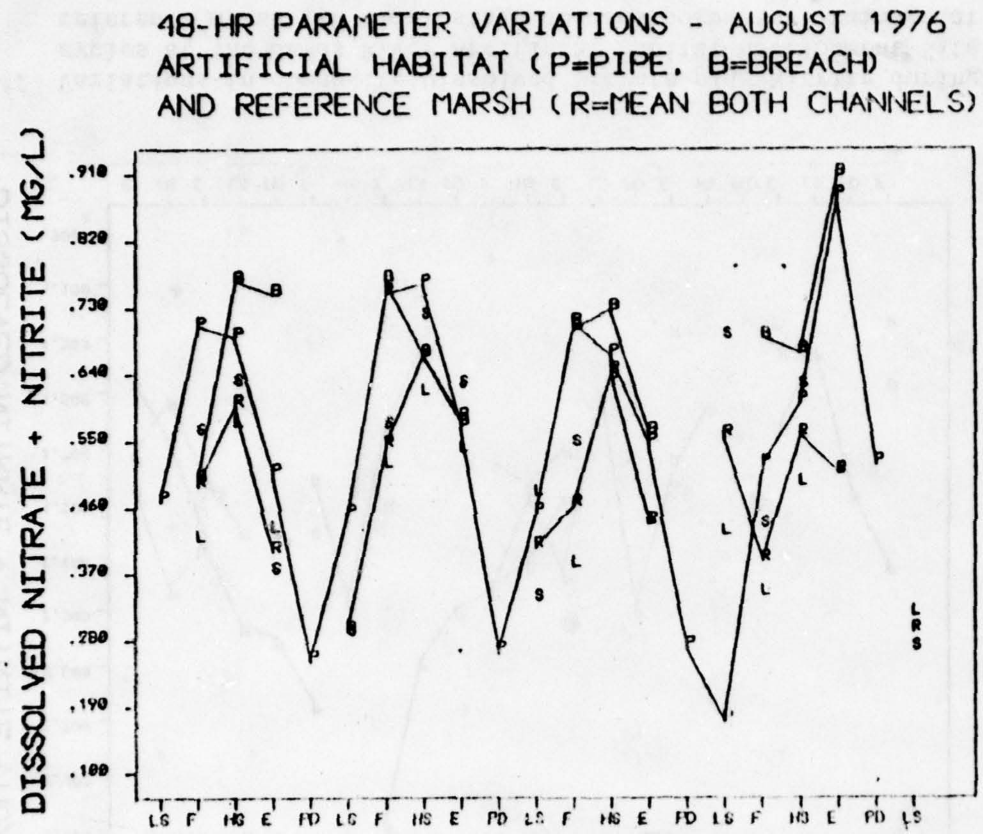

Figure A'63. Variations in composite Dissolved Nitrate plus Nitrite during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (PD tidal stage denotes porewater drainage at the pipe; L = large channel, S = small channel at the reference marsh).

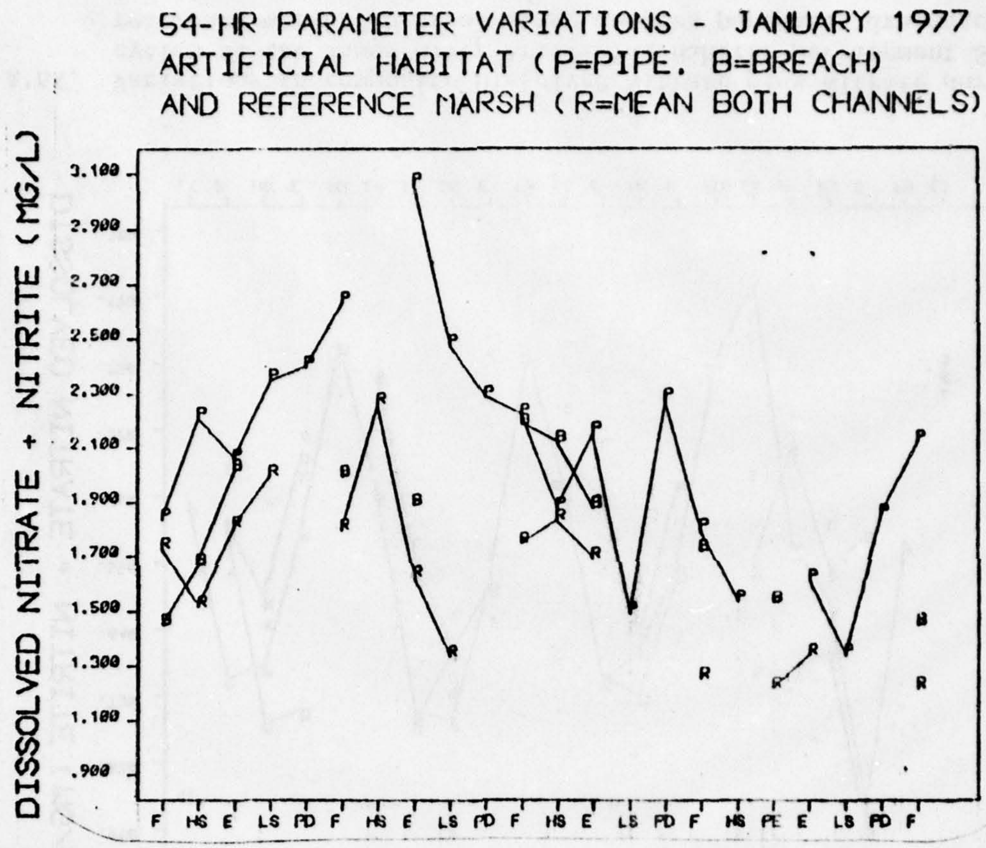

Figure A'64. Variations in composite Dissolved Nitrate plus Nitrite during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (PD tidal stage denotes porewater drainage at the pipe).

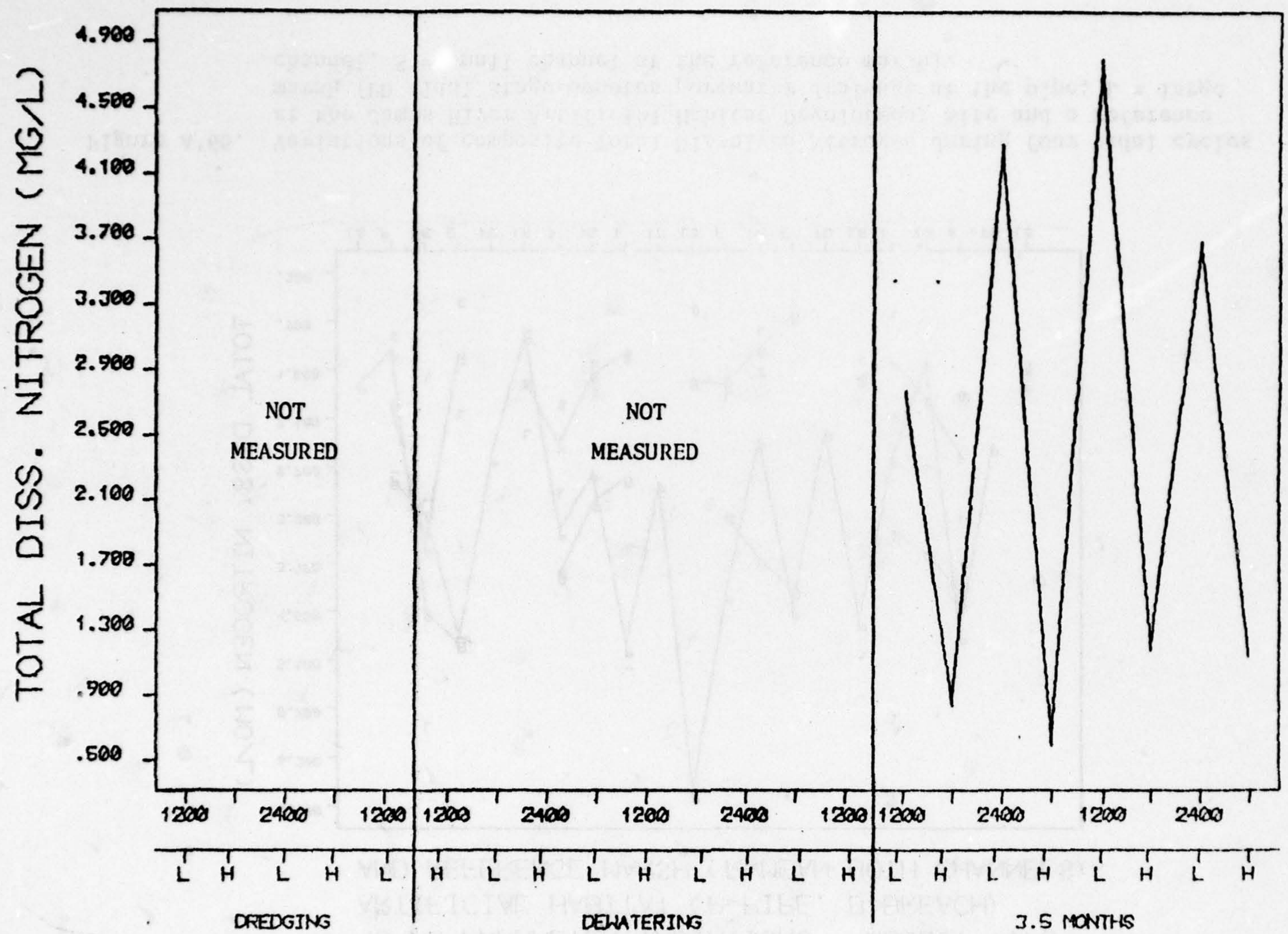

Figure A'65. Variations in Total Dissolved Nitrogen during the 3.5 month post-dredging period at the James River intertidal diked containment area, Virginia, during May 1975.

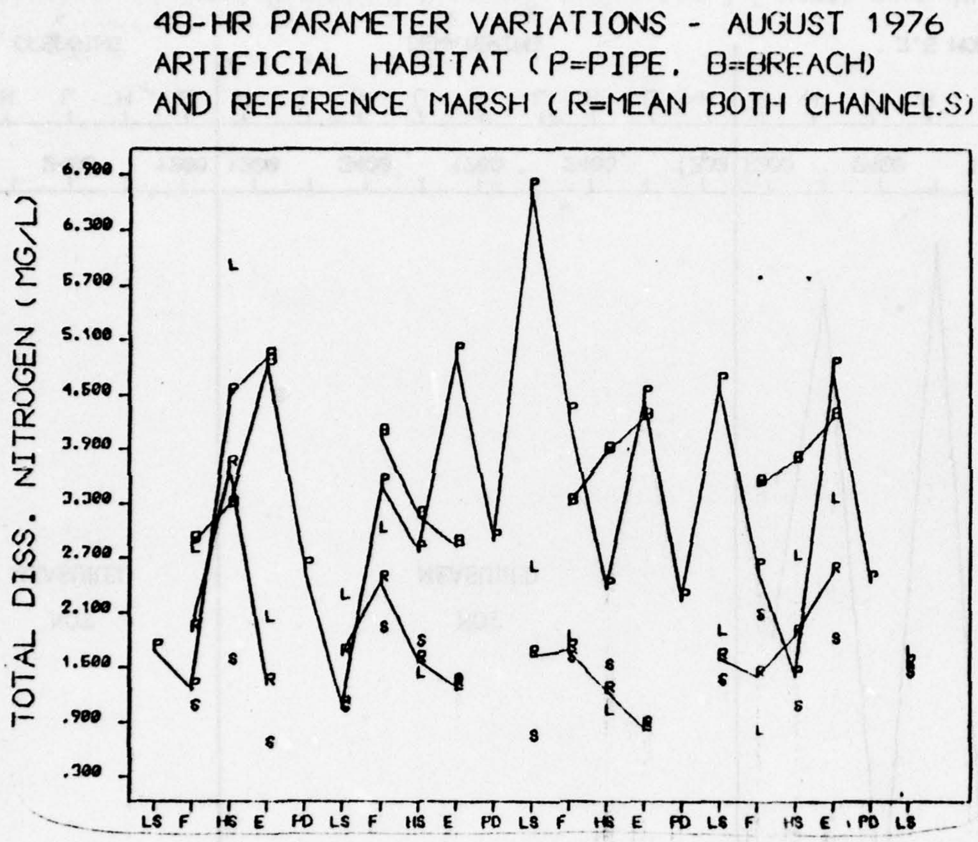

Figure A'66. Variations of composite Total Dissolved Nitrogen during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (PD tidal stage denotes porewater drainage at the pipe; L = large channel, S = small channel at the reference marsh).

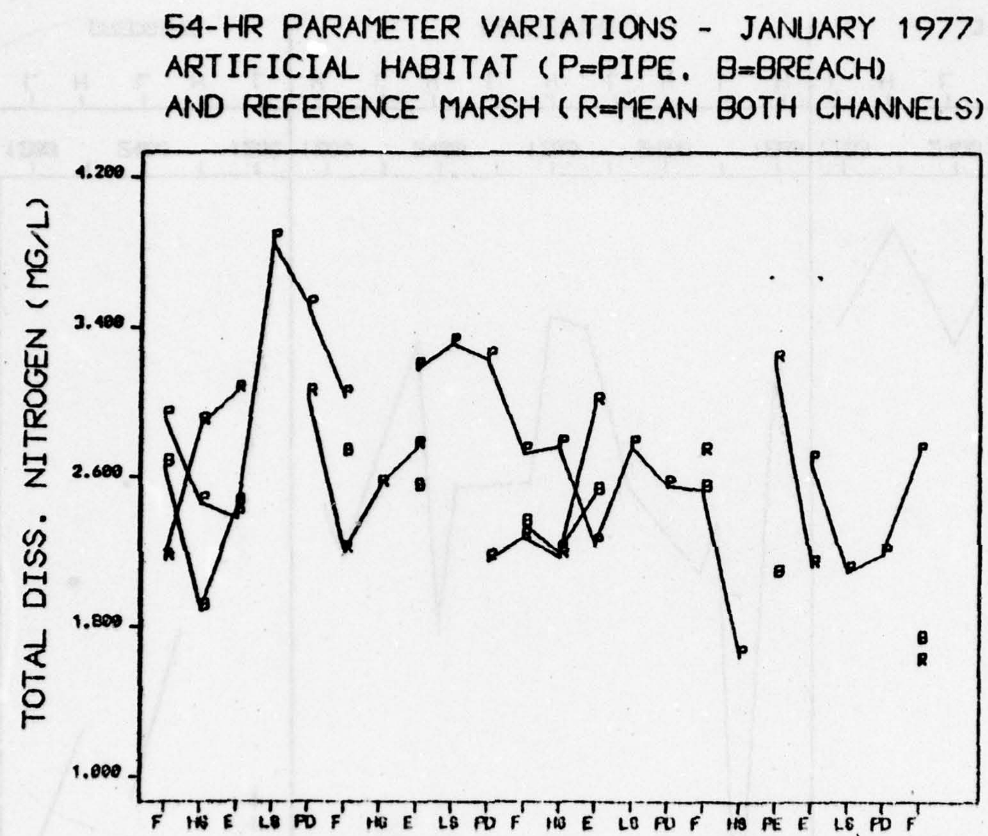

Figure A'67. Variations of composite Total Dissolved Nitrogen during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (PD tidal stage denotes porewater drainage at the pipe).

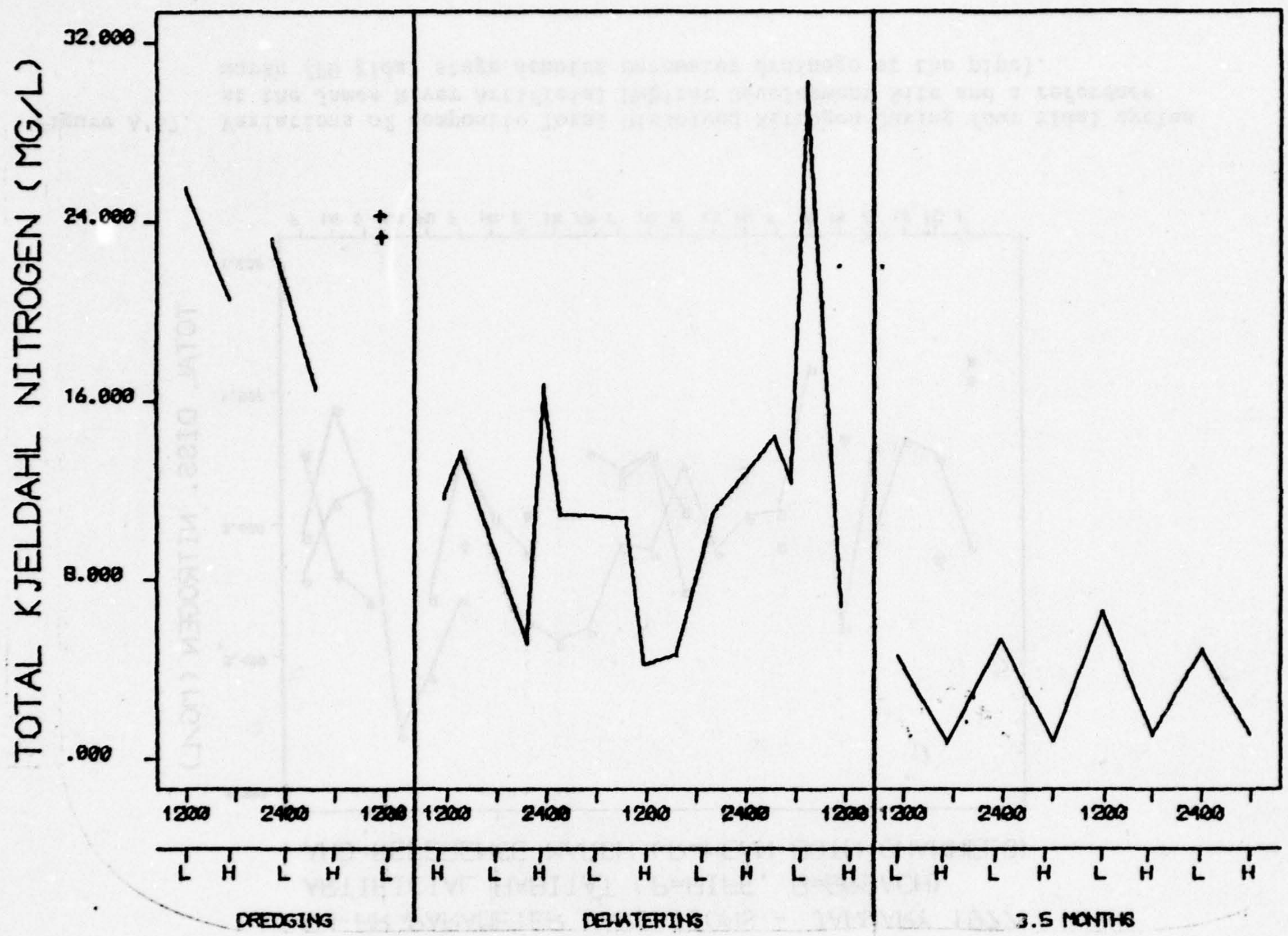

Figure A'68. Temporal changes in Total Kjeldahl Nitrogen during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, during Jan-May 1975 (+ = samples collected 15 minutes apart).

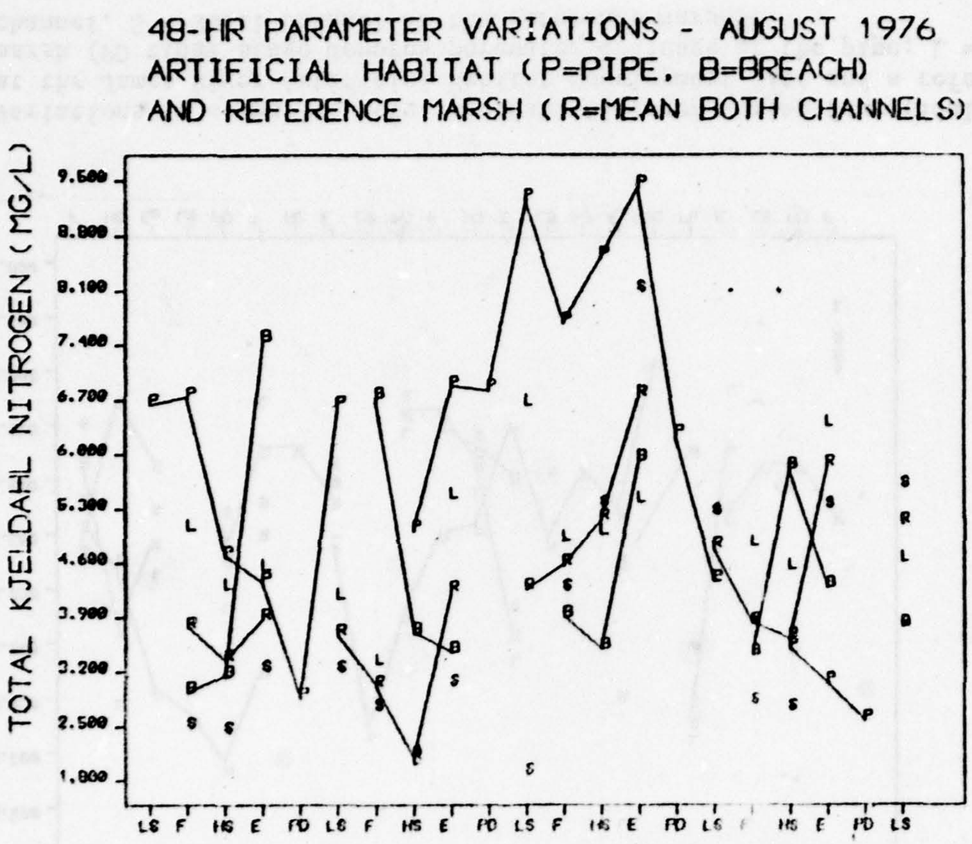

Figure A'69. Variations in composite Total Kjeldahl Nitrogen during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (PD tidal stage denotes porewater drainage at the pipe; L = large channel, S = small channel at the reference marsh).

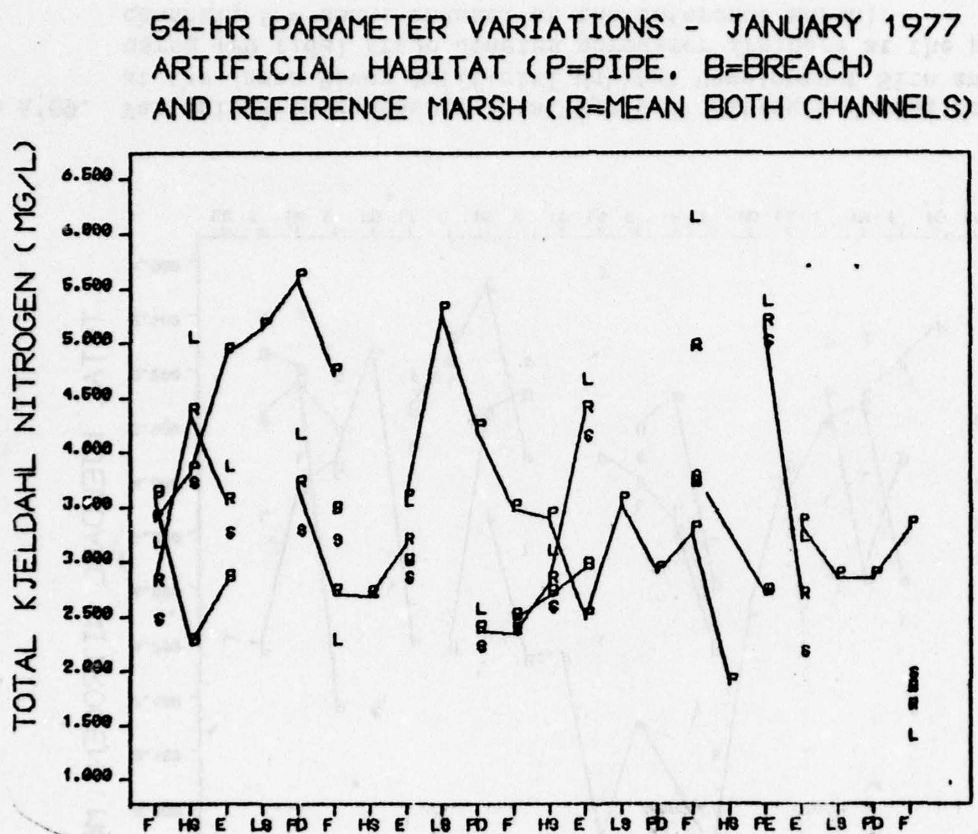

Figure A'70. Variations in composite Total Kjeldahl Nitrogen during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (PD tidal stage denotes porewater drainage at the pipe; L = large channel, S = small channel at the reference marsh).

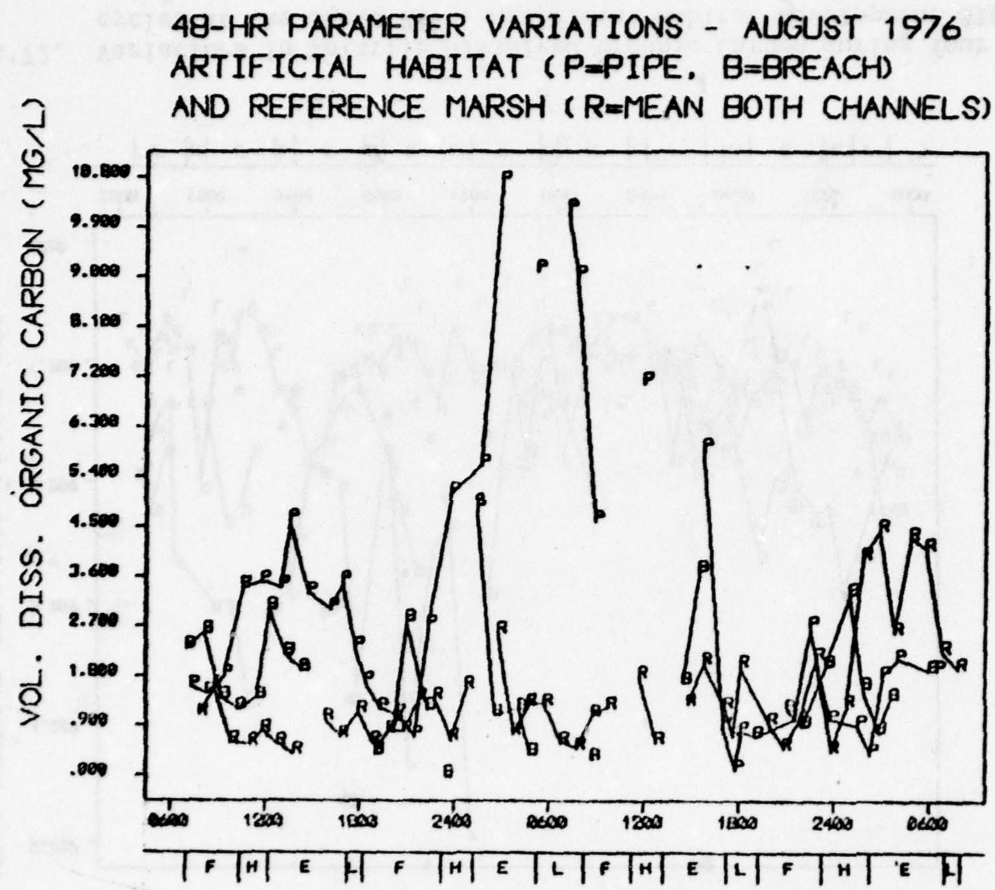

Figure A'71. Variations in Volatile Dissolved Organic Carbon during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh.

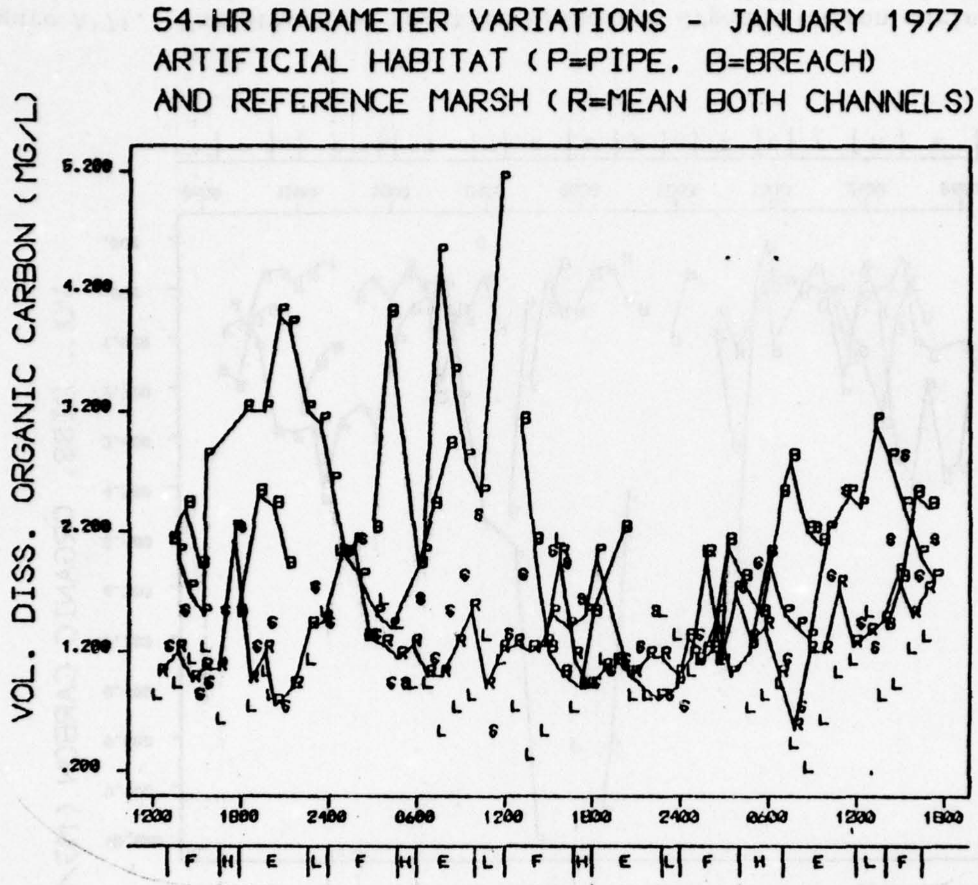

Figure A'72. Variations in Volatile Dissolved Organic Carbon during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (L = large channel, S = small channel).

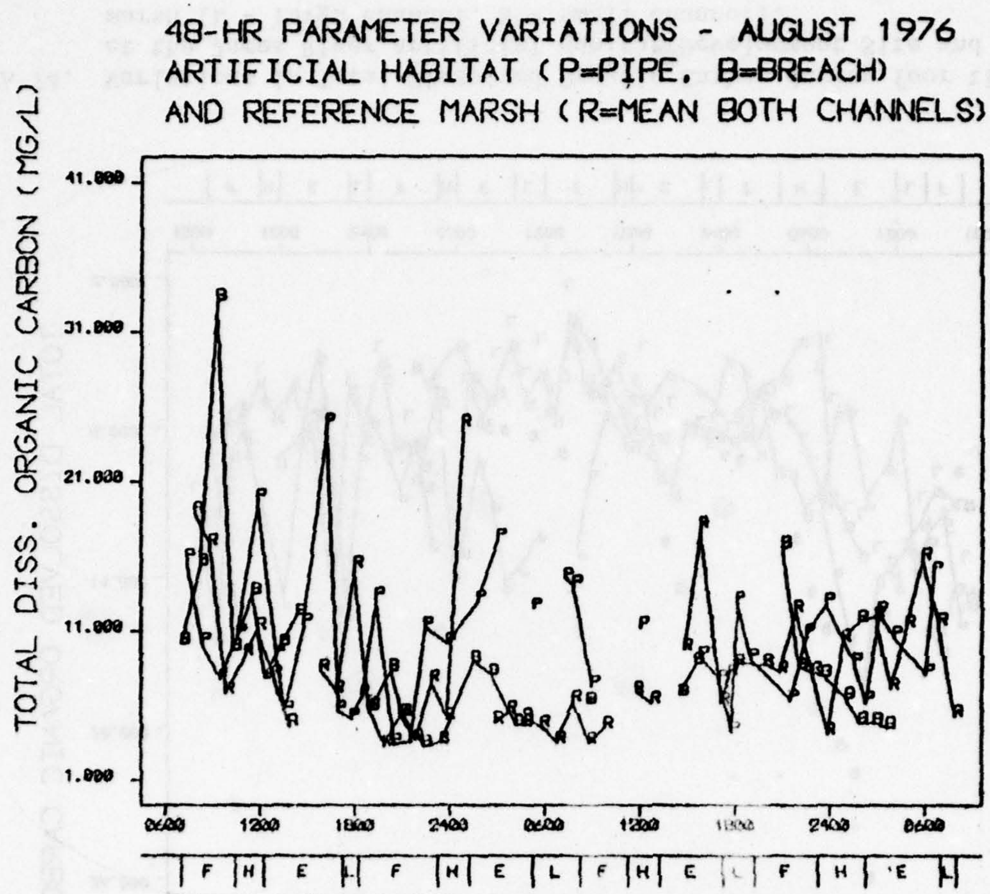

Figure A'73. Variations in Total Dissolved Organic Carbon during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh.

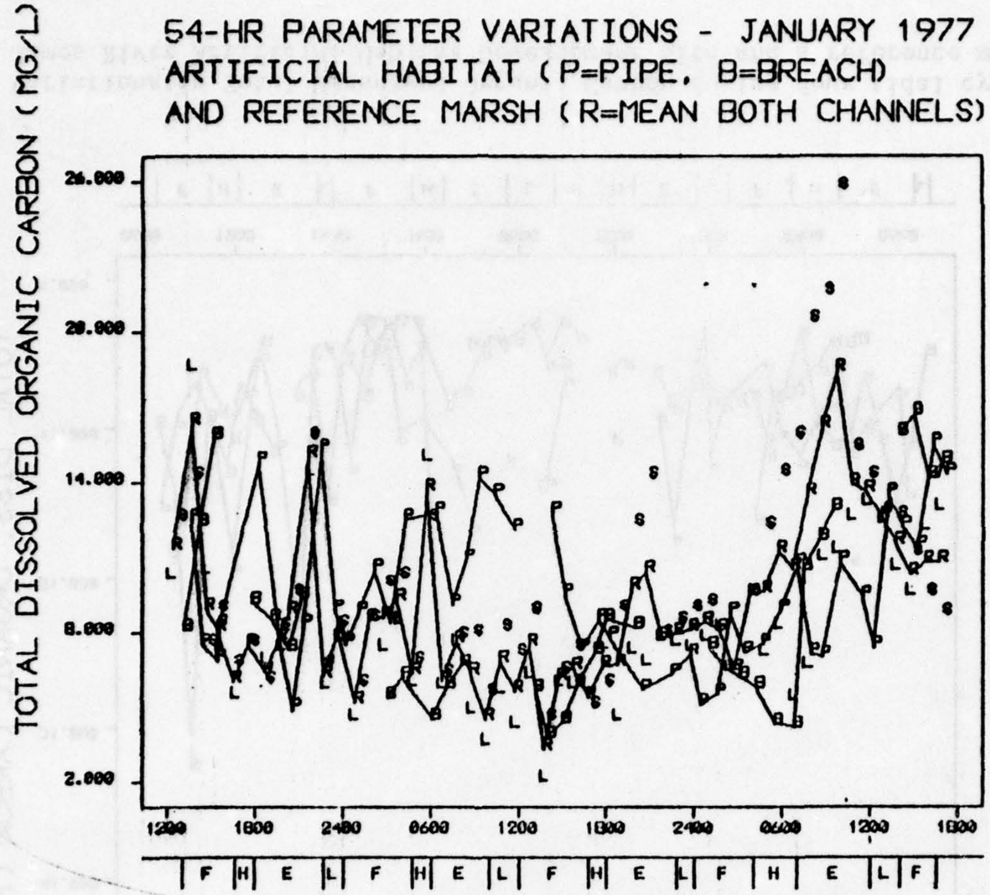

Figure A'74. Variations in Total Dissolved Organic Carbon during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (L = large channel, S = small channel).

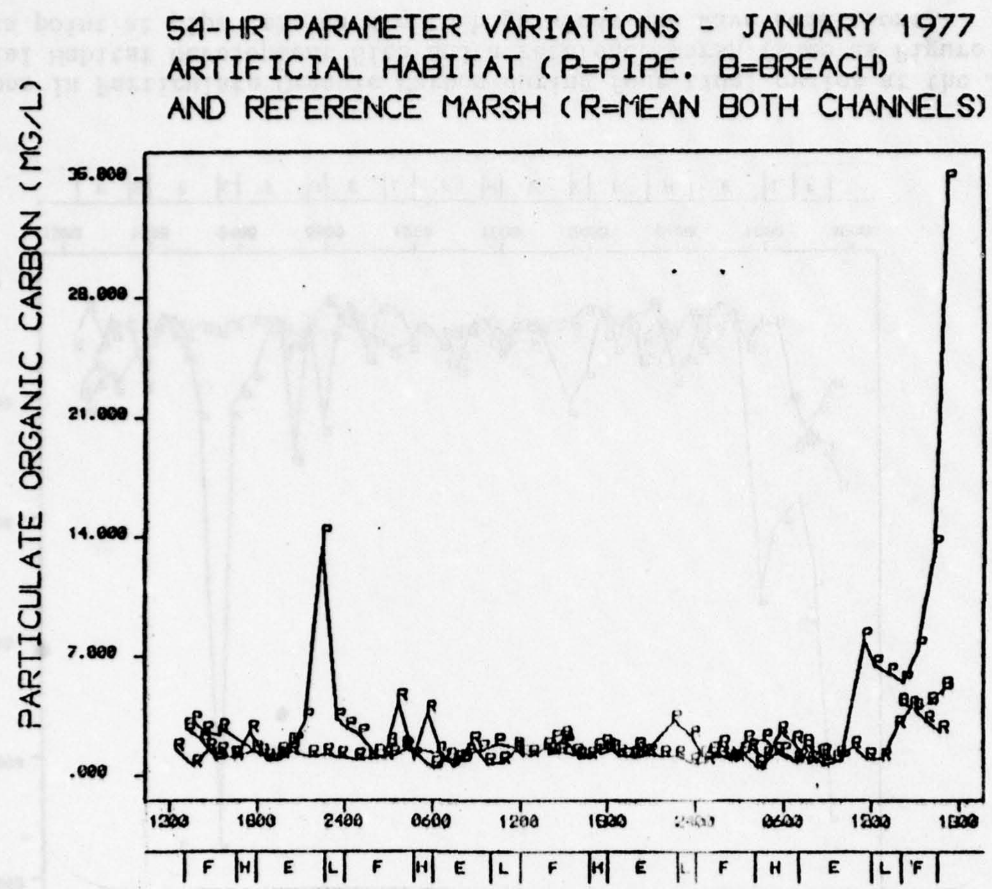

Figure A'75. Variations in Particulate Organic Carbon during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (see Figure A'76 as well).

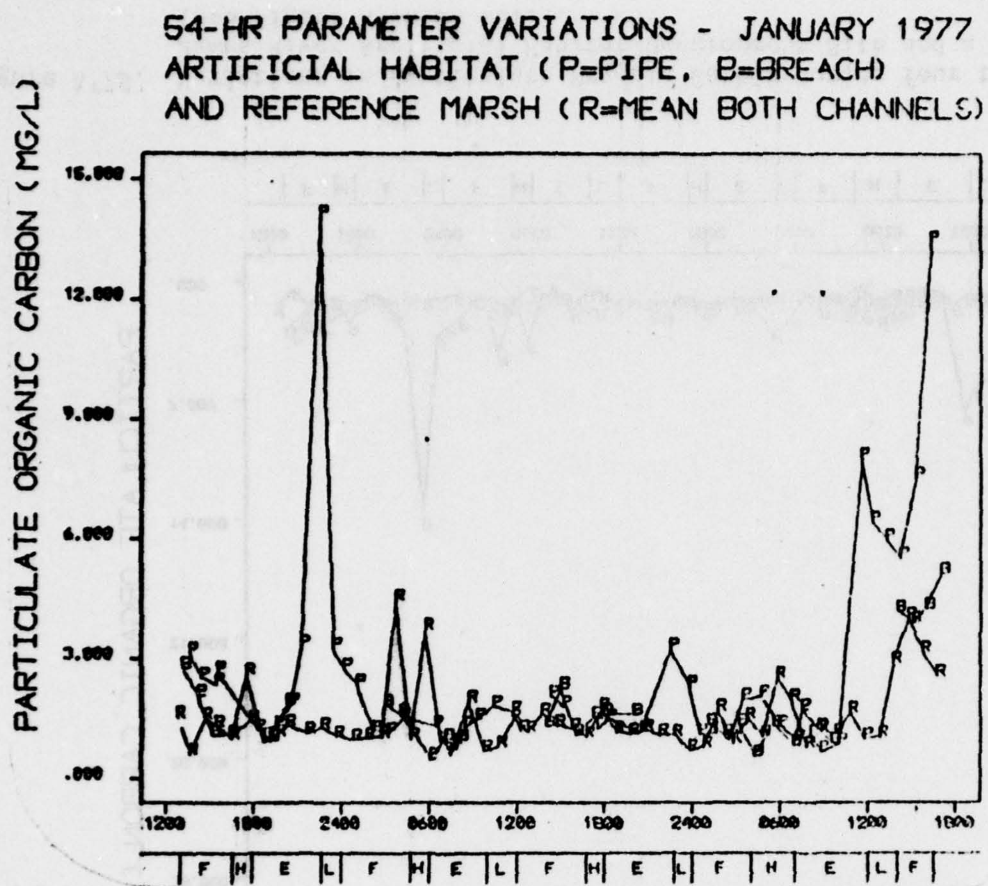

Figure A'76. Variations in Particulate Organic Carbon during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (same as Figure A'75 except last data point at pipe deleted due to high winds and wave conditions).

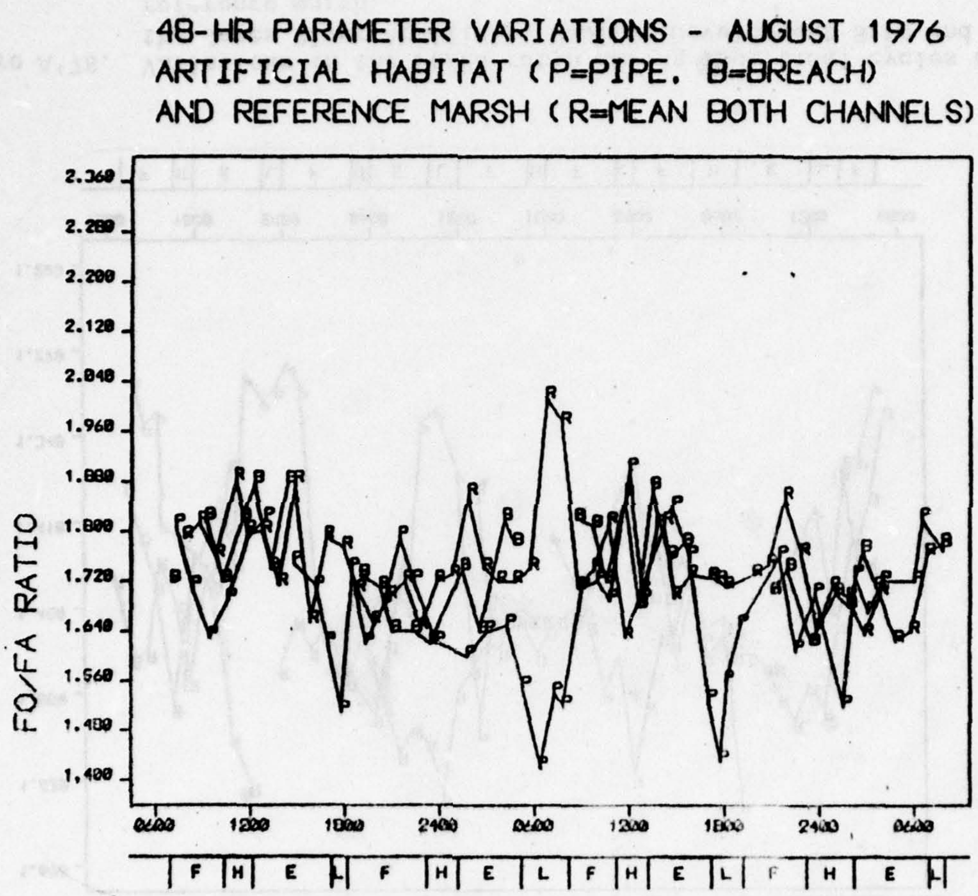

Figure A'77. Variations in the Fo/Fa ratio during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh.

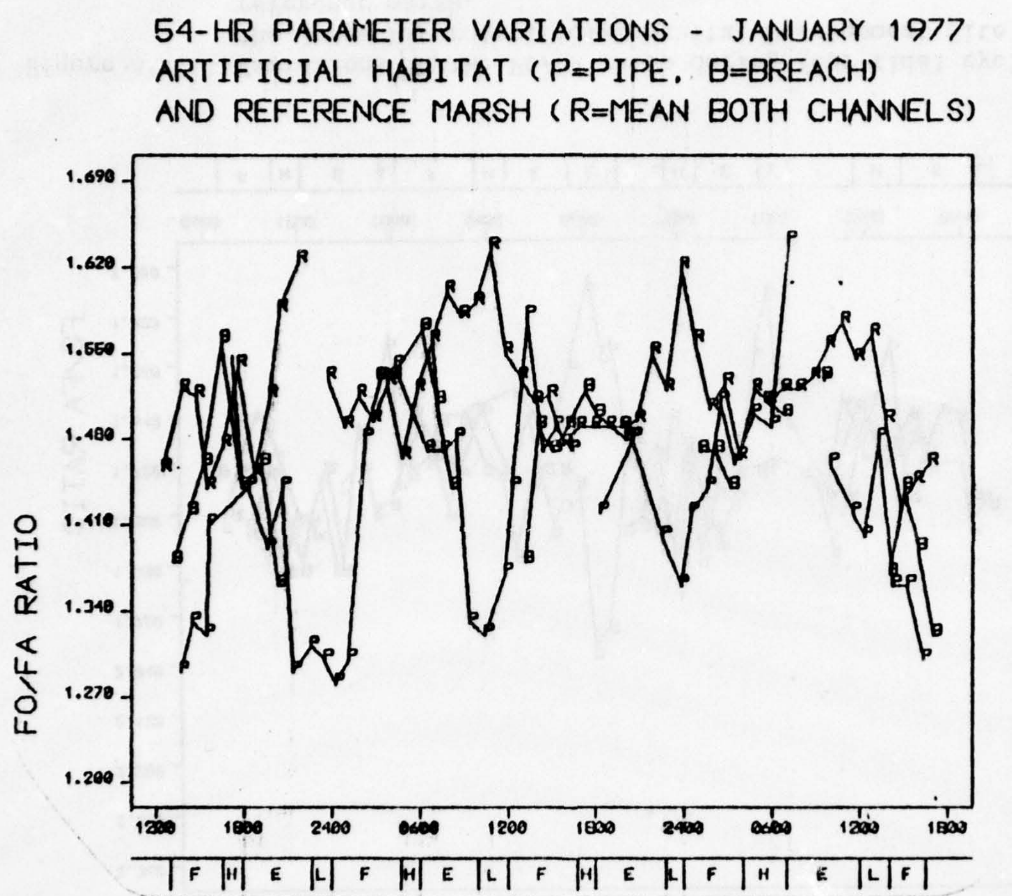

Figure A'78. Variations in the Fo/Fa ratio during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh.

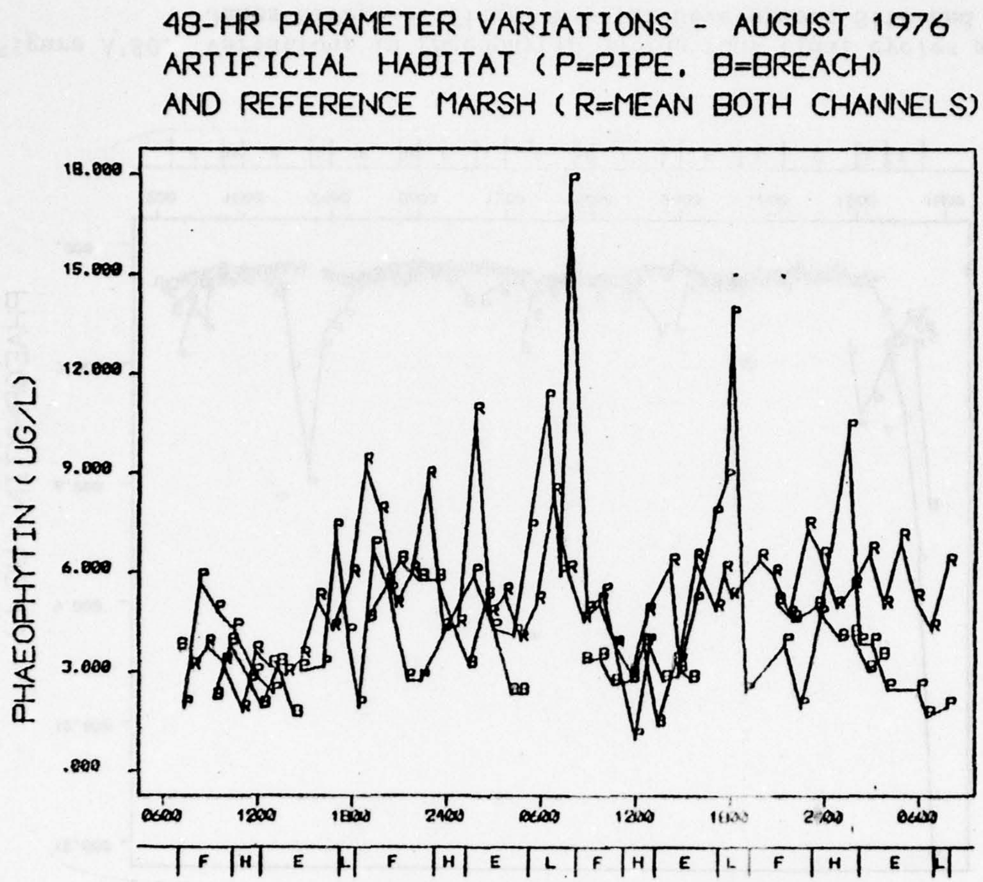

Figure A'79. Variations in Phaeophytin during four tidal cycles at the James River Artifical Habitat Development Site and a reference marsh.

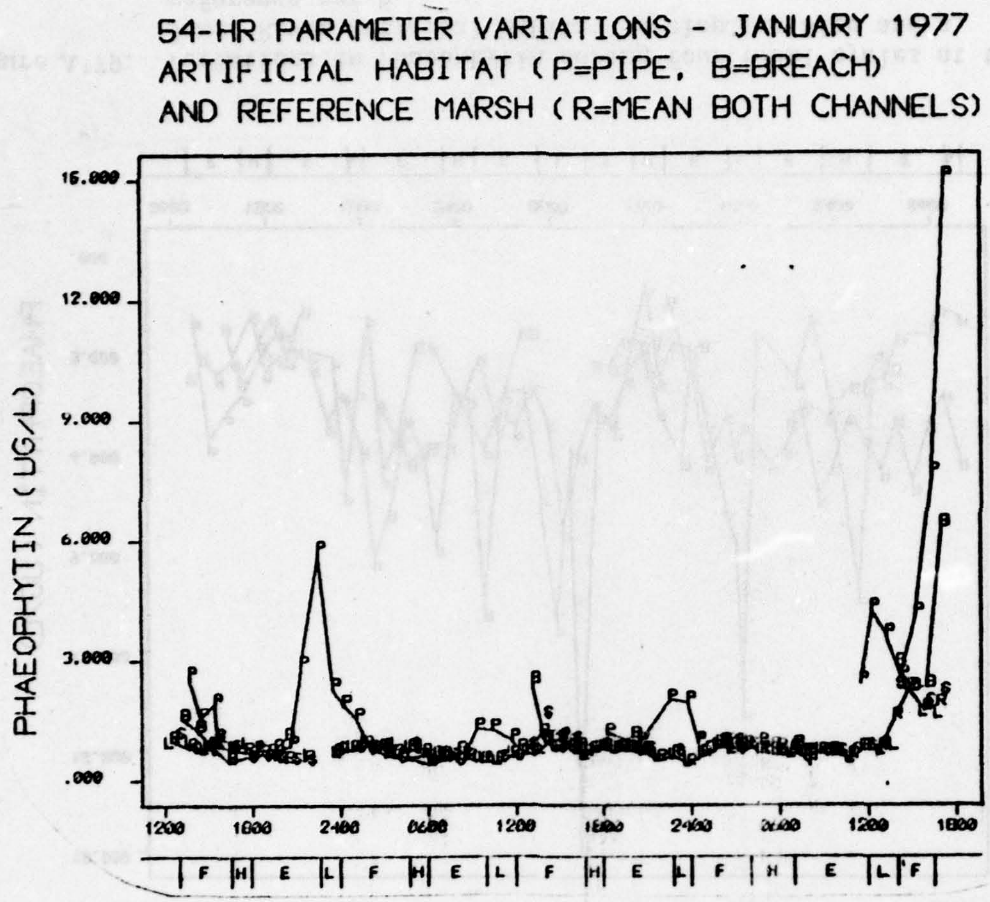

Figure A'80. Variations in Phaeophytin during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (see Figure A'81 as well; L = large channel, S = small channel at the reference marsh).

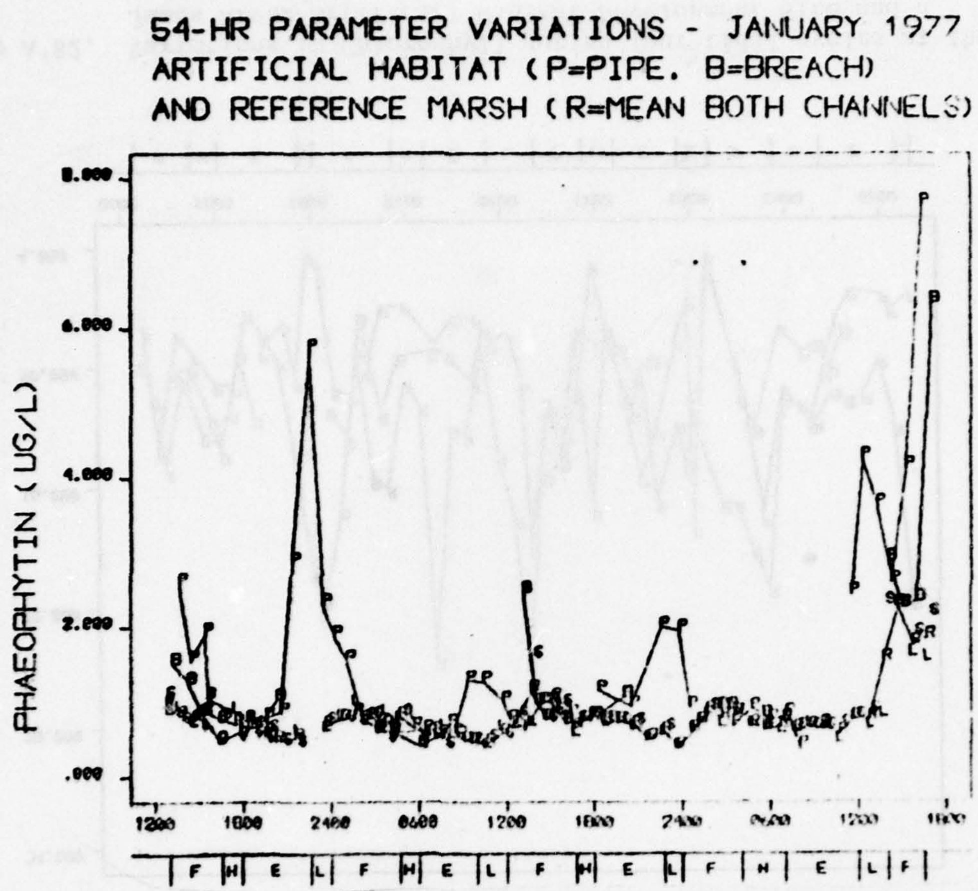

Figure A'81. Variations in Phaeophytin during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (same as Figure A'80 except last data point at pipe deleted due to high winds and wave conditions; L = large channel, S = small channel at the reference marsh).

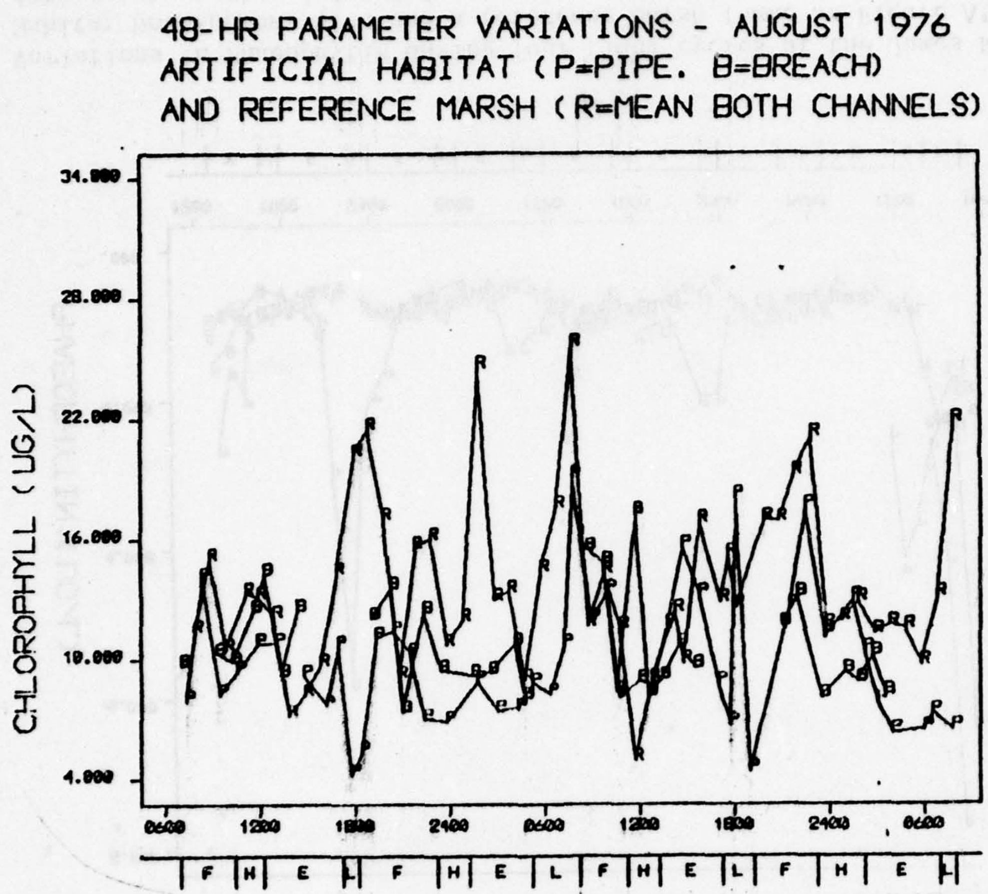

Figure A'82. Variations in Chlorophyll during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh.

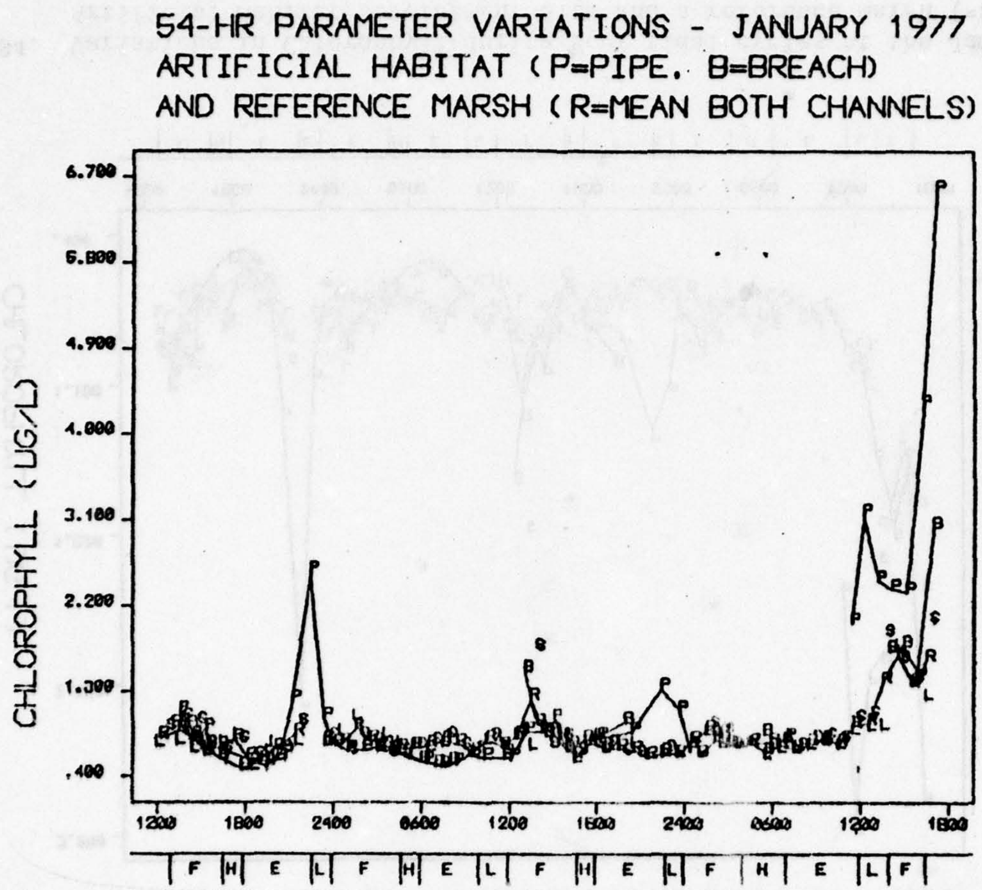

Figure A'83. Variations in Chlorophyll during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (see Figure A'84 as well; L = large channel, S = small channel at the reference marsh).

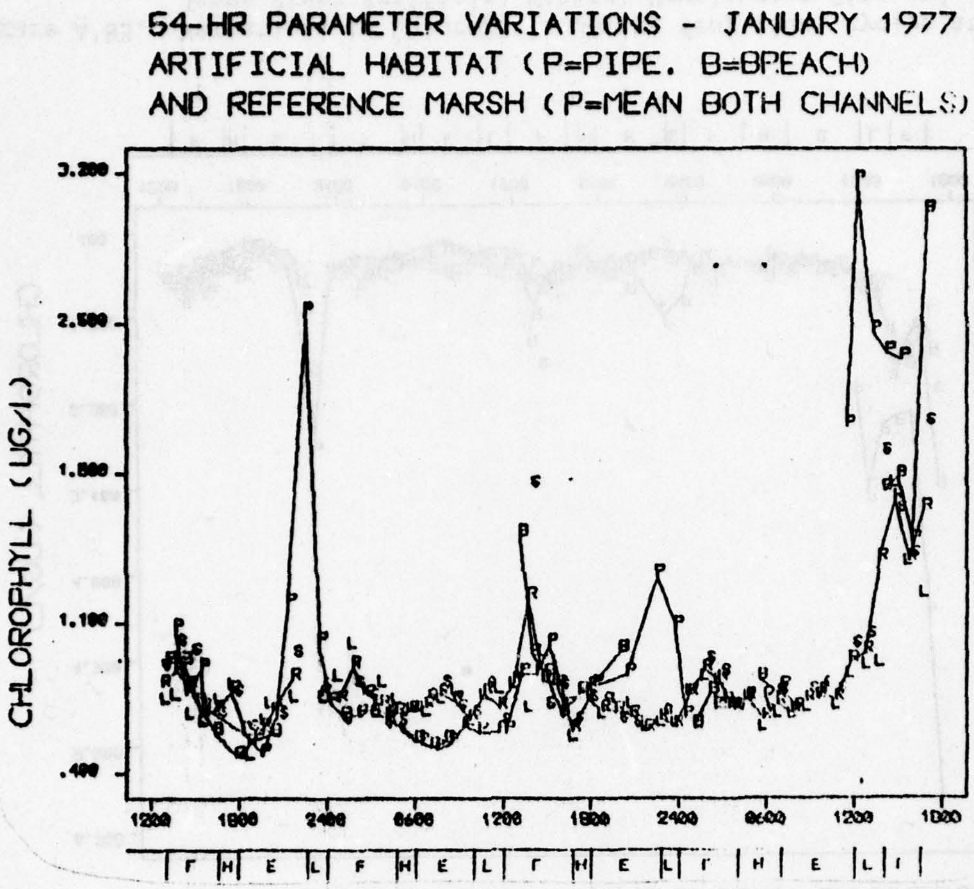

Figure A'84. Variations in Chlorophyll during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (same as Figure A'83 except the last two data points at pipe deleted due to high winds and wave conditions).

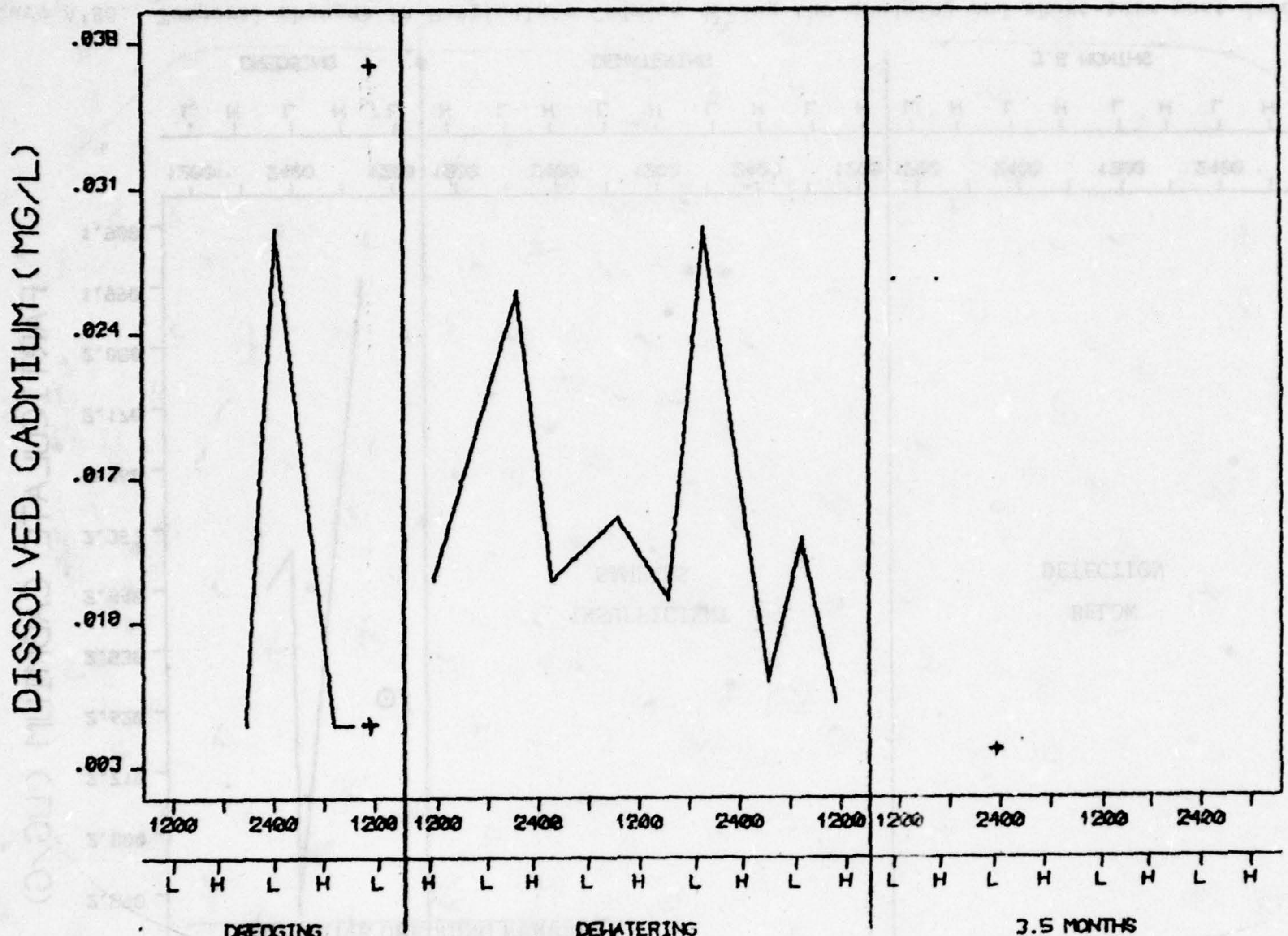

Figure A'85. Temporal changes in Dissolved Cadmium during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, during Jan-May 1975 (+ = samples collected 15 minutes apart during dredging period).

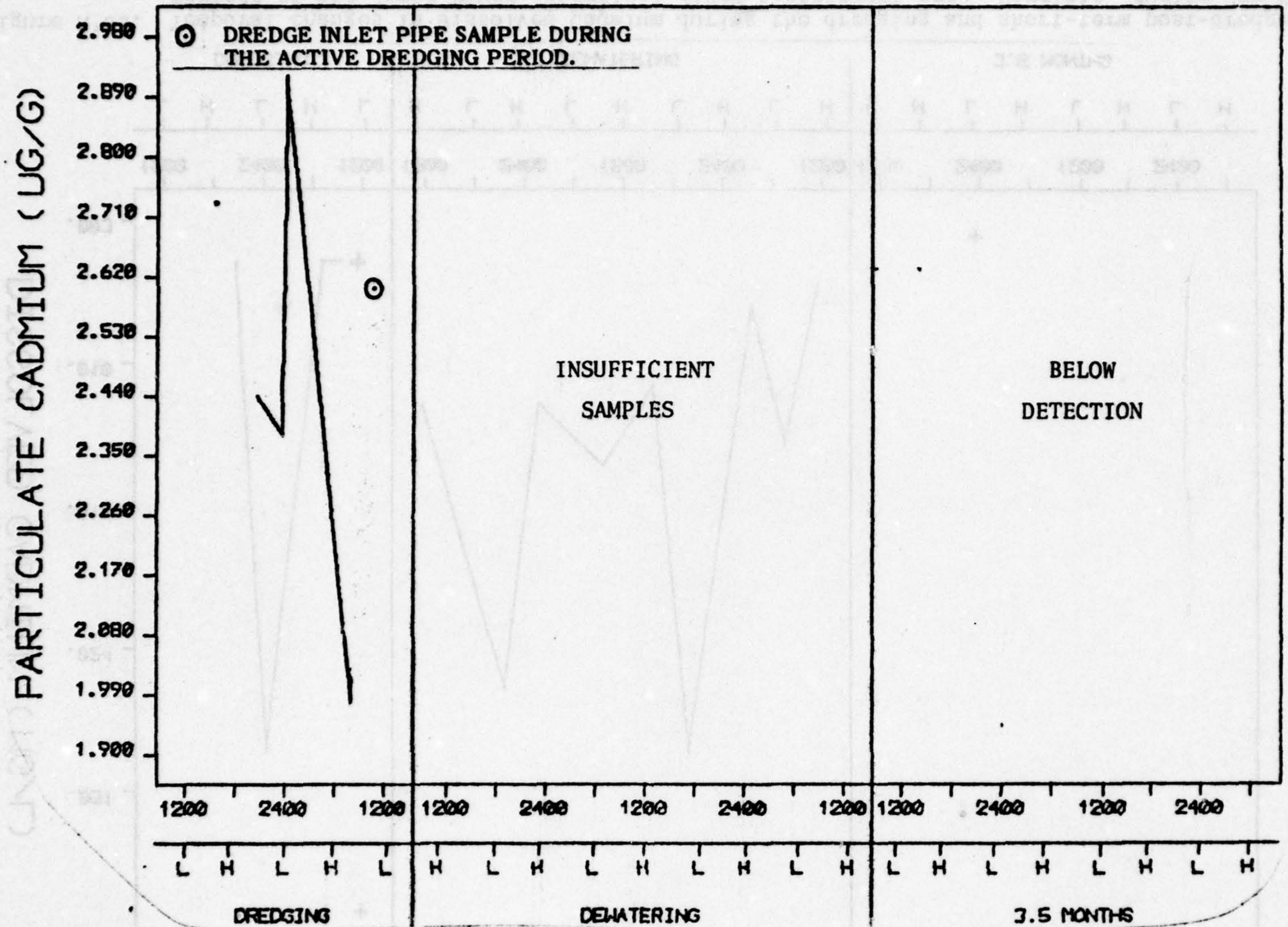

Figure A'86. Temporal changes in Particulate Cadmium during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, Jan-May 1975.

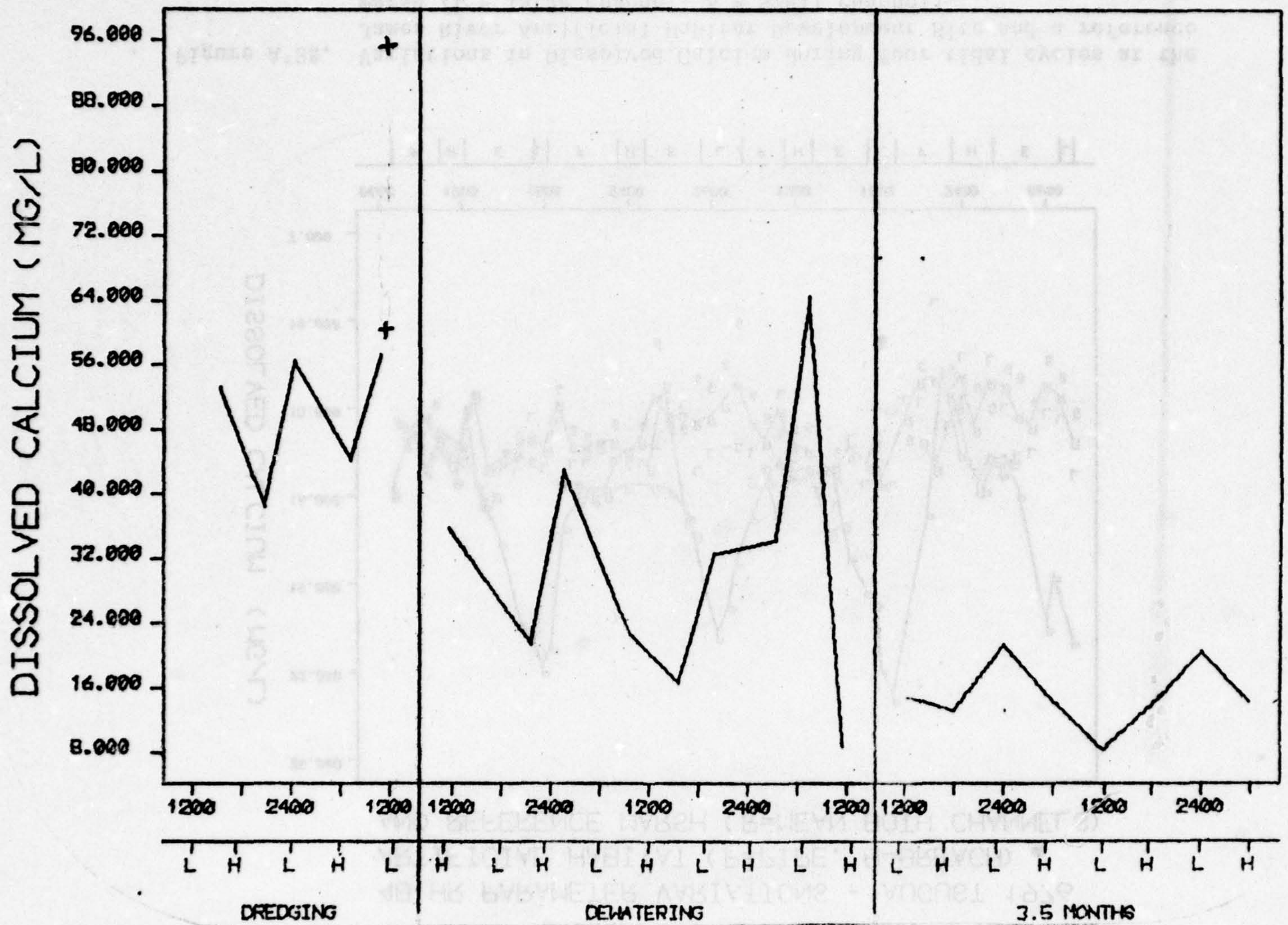

Figure A'87. Temporal changes in Dissolved Calcium during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, Jan-May 1975 (+ = samples collected 15 minutes apart).

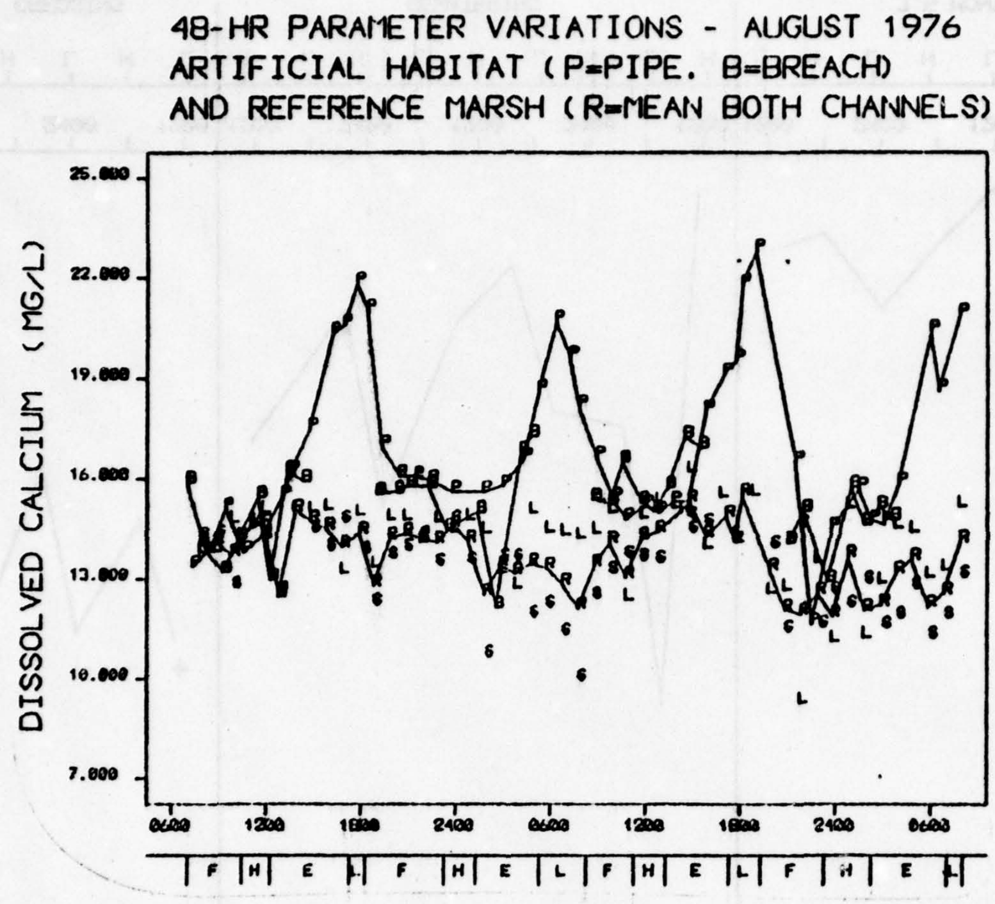

Figure A'88. Variations in Dissolved Calcium during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (L = large channel, S = small channel).

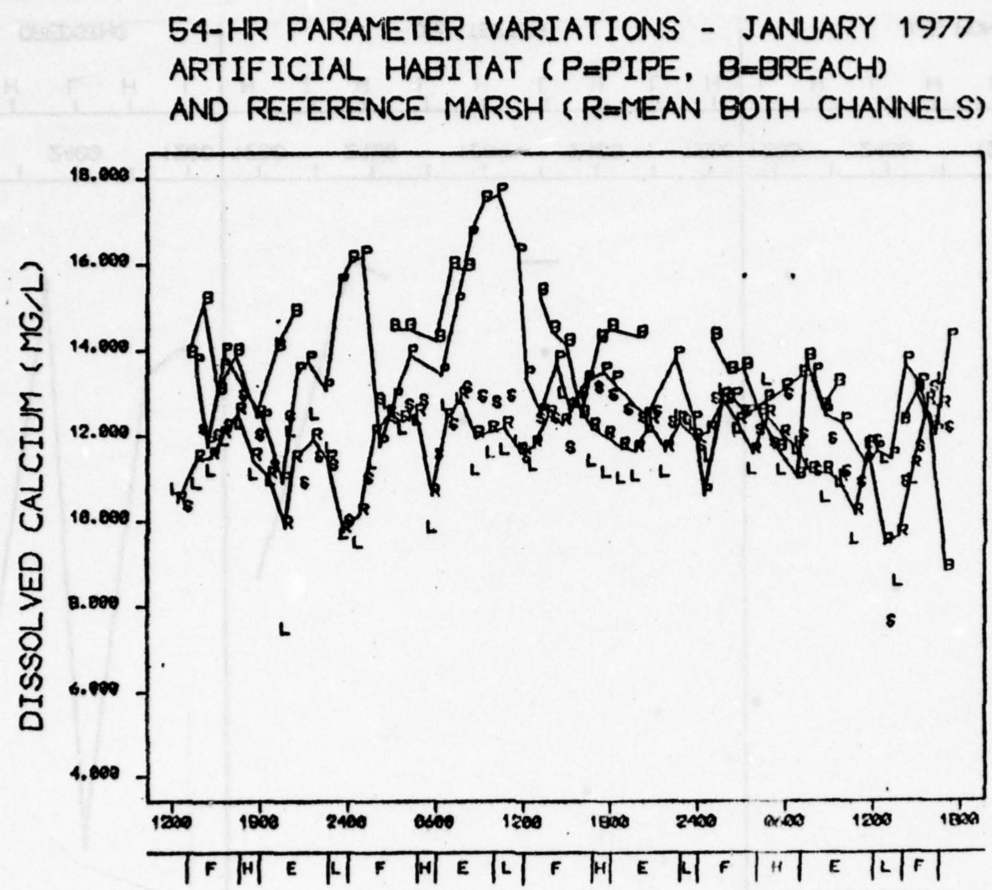

Figure A'89. Variations in Dissolved Calcium during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (L = large channel, S = small channel).

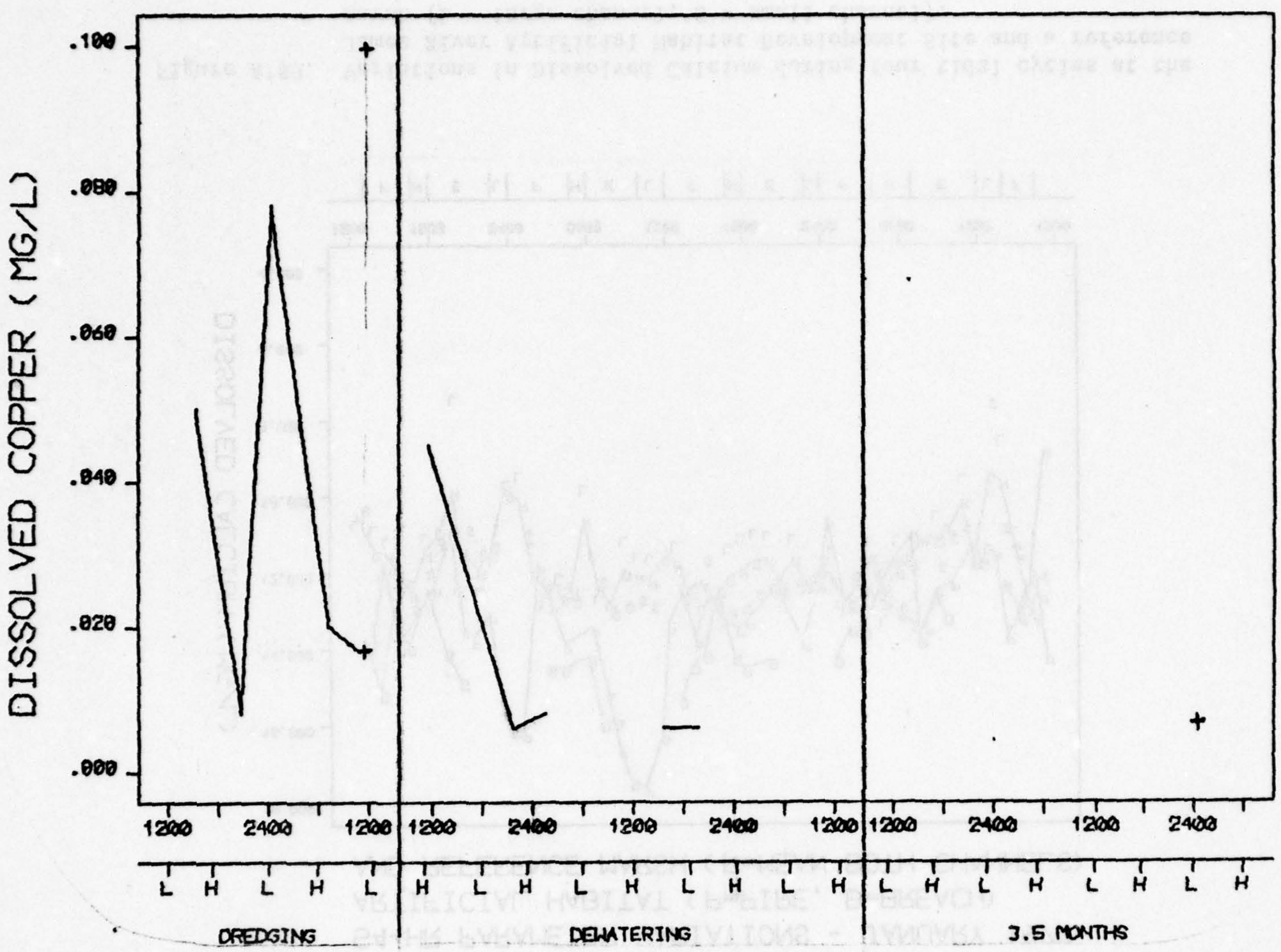

Figure A'90. Temporal changes in Dissolved Copper during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, Jan-May 1975 (+ samples collected 15 minutes apart during dredging period).

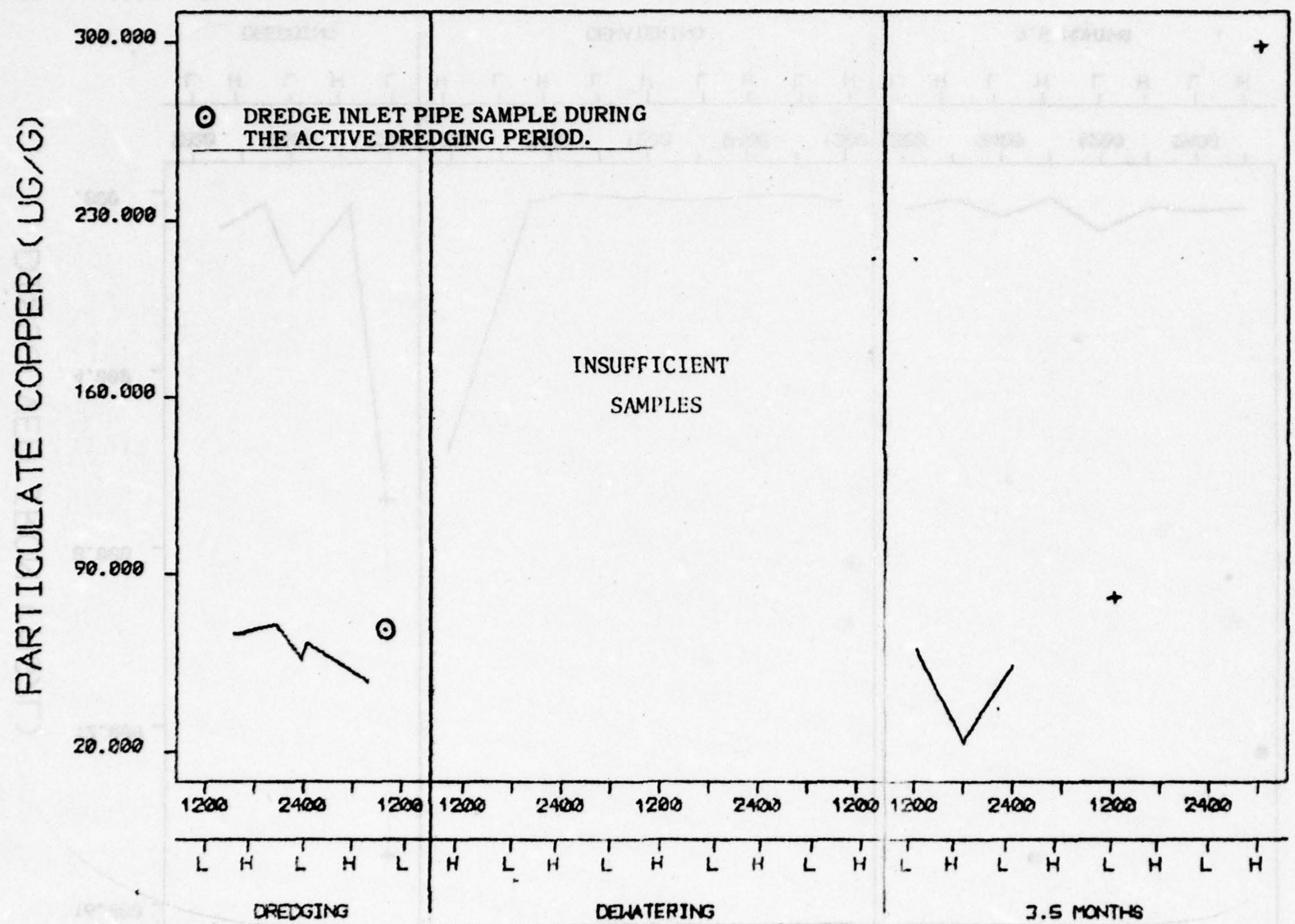

Figure A'91. Temporal changes in Particulate Copper during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, Jan-May 1975.

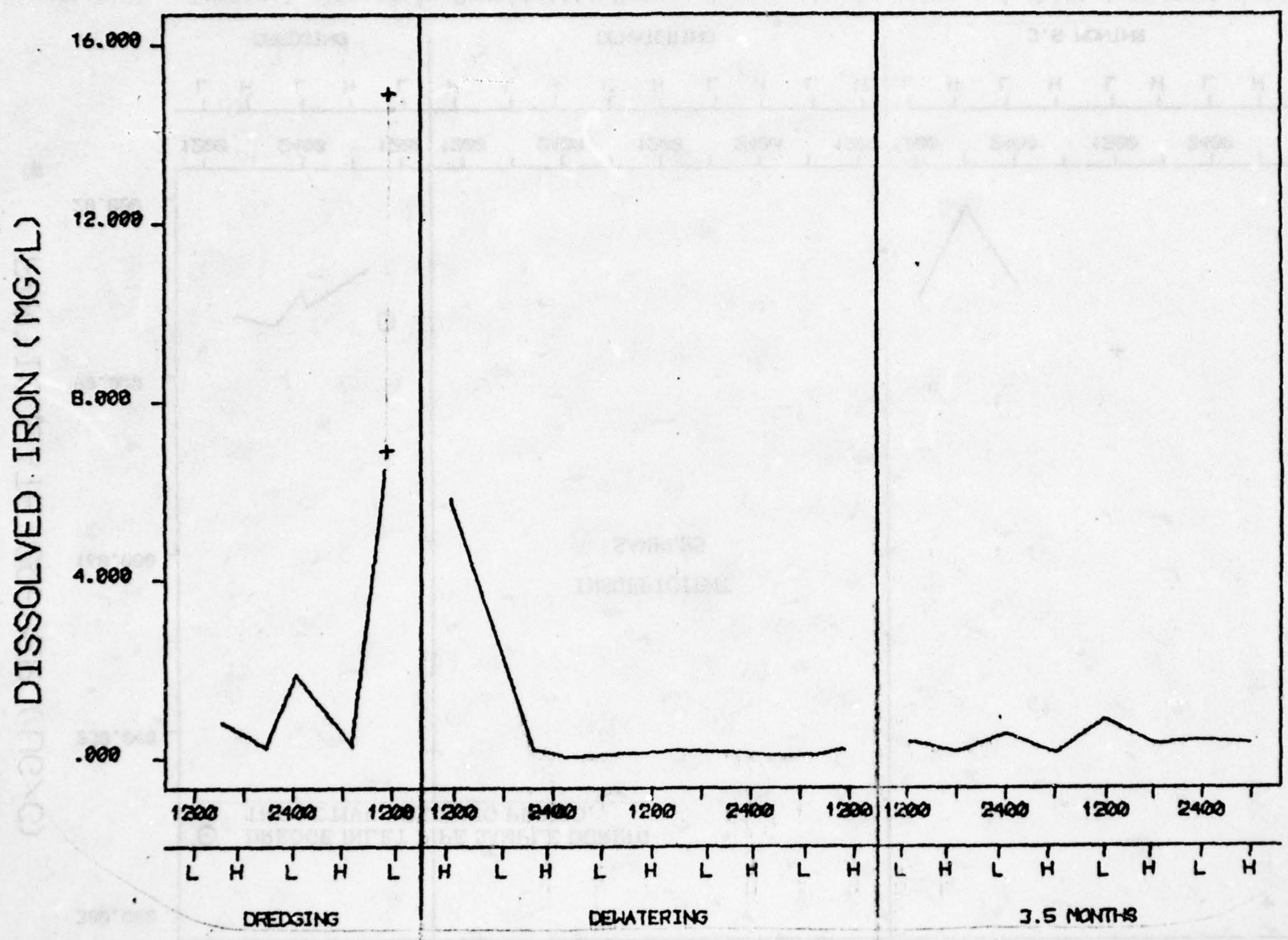

Figure A'92. Temporal changes in Dissolved Iron during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, Jan-May 1975 (+ = samples collected 15 minutes apart).

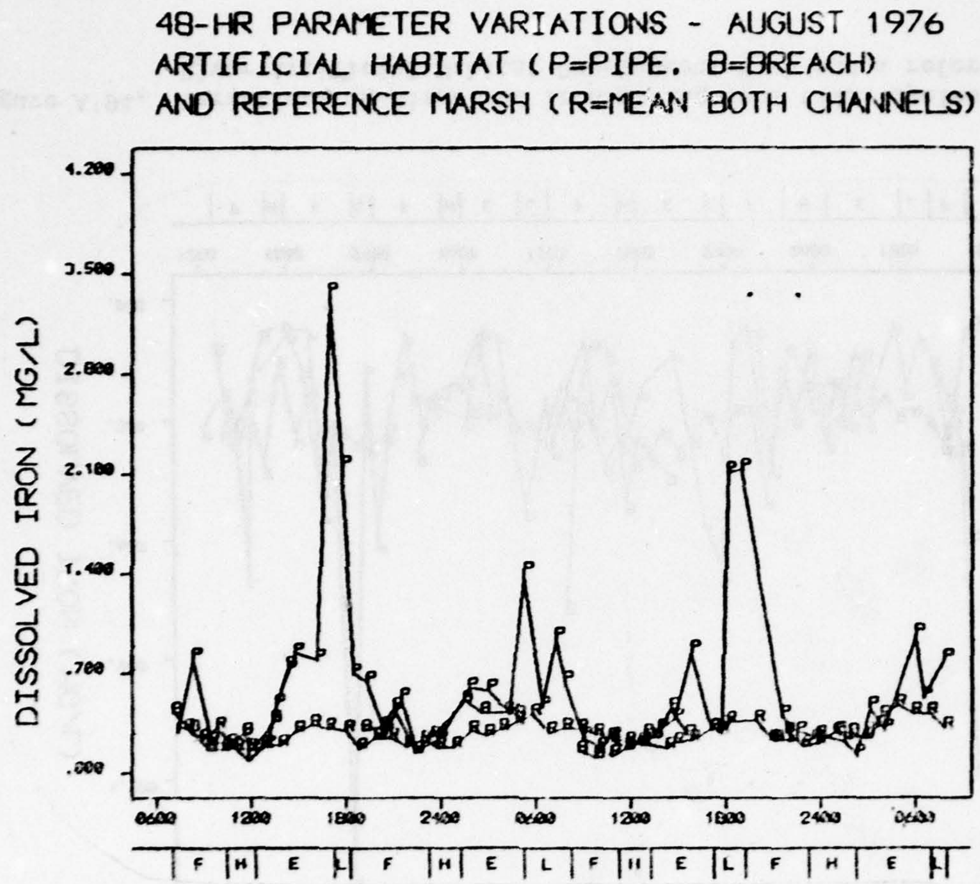

Figure A'93. Variations in Dissolved Iron during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh.

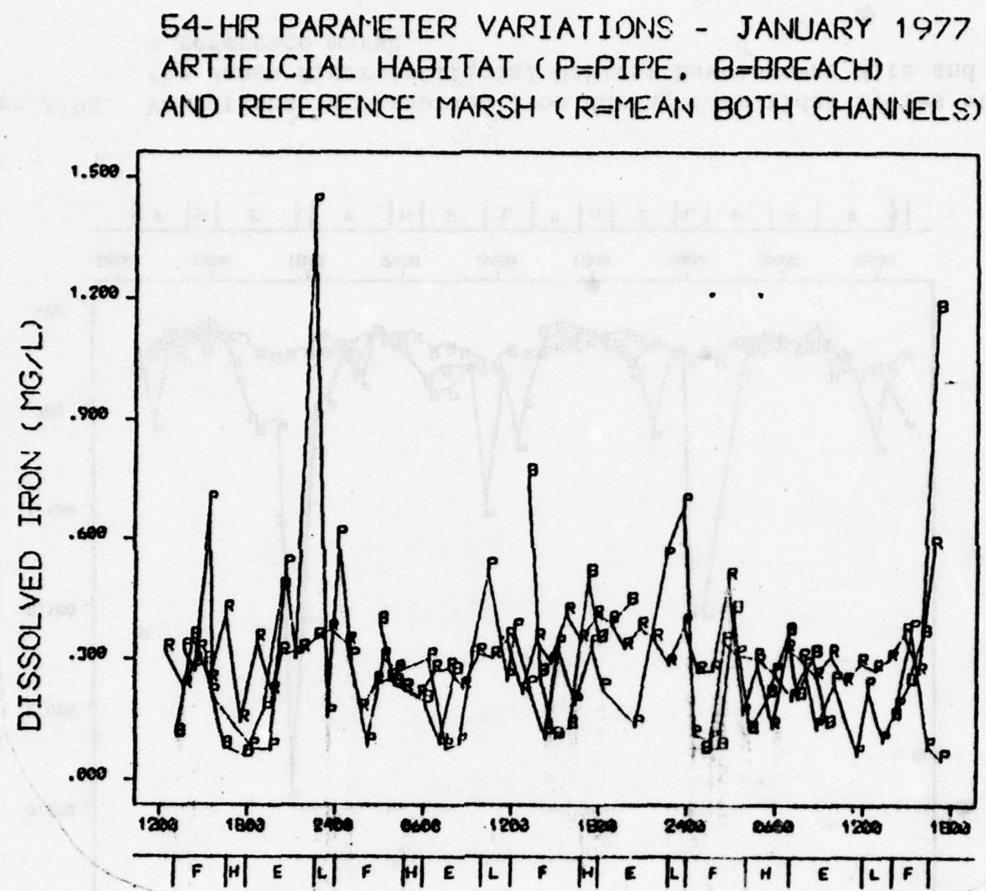

Figure A'94. Variations in Dissolved Iron during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh.

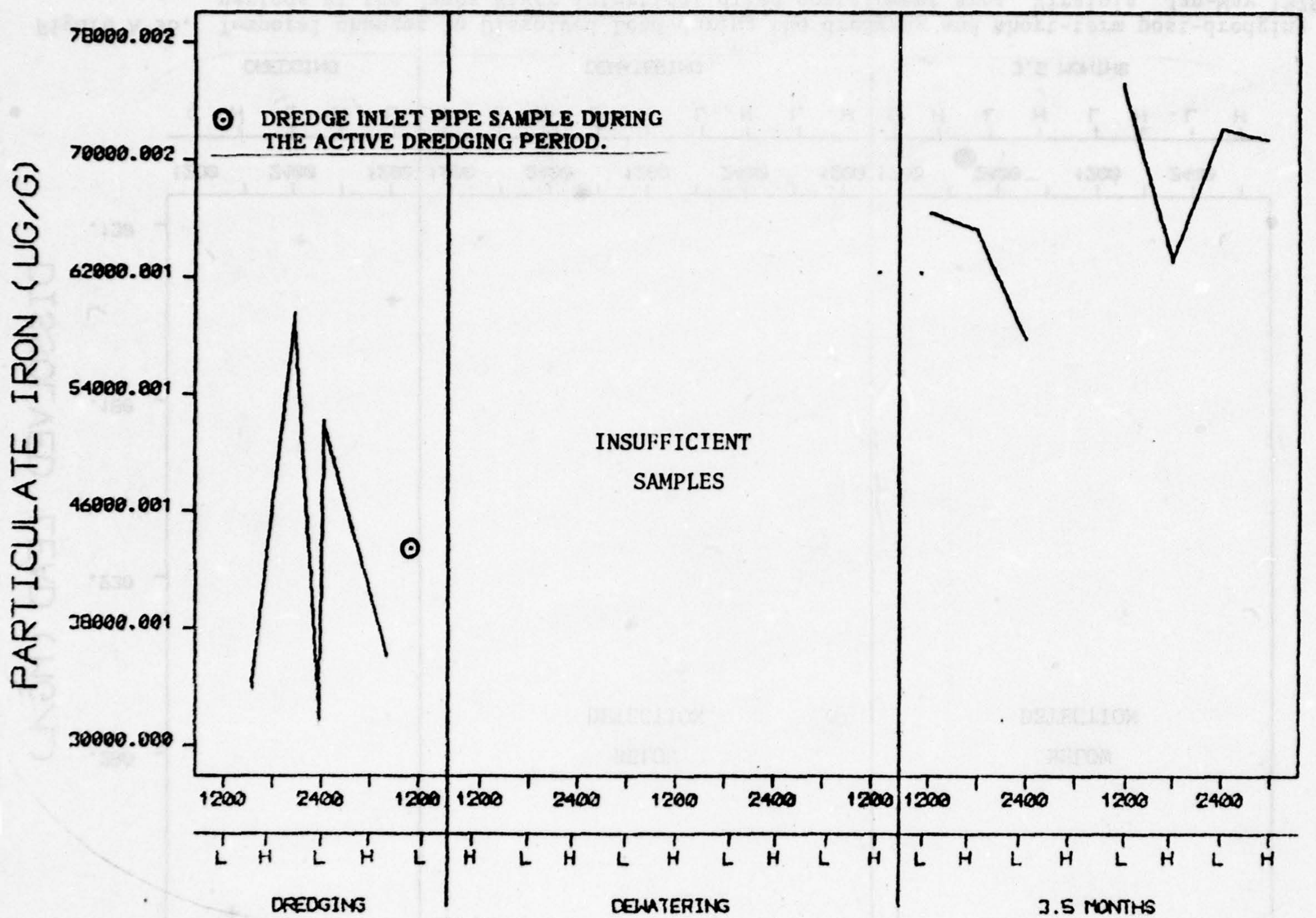

Figure A'95, Temporal changes in Particulate Iron during dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, Jan-May 1975.

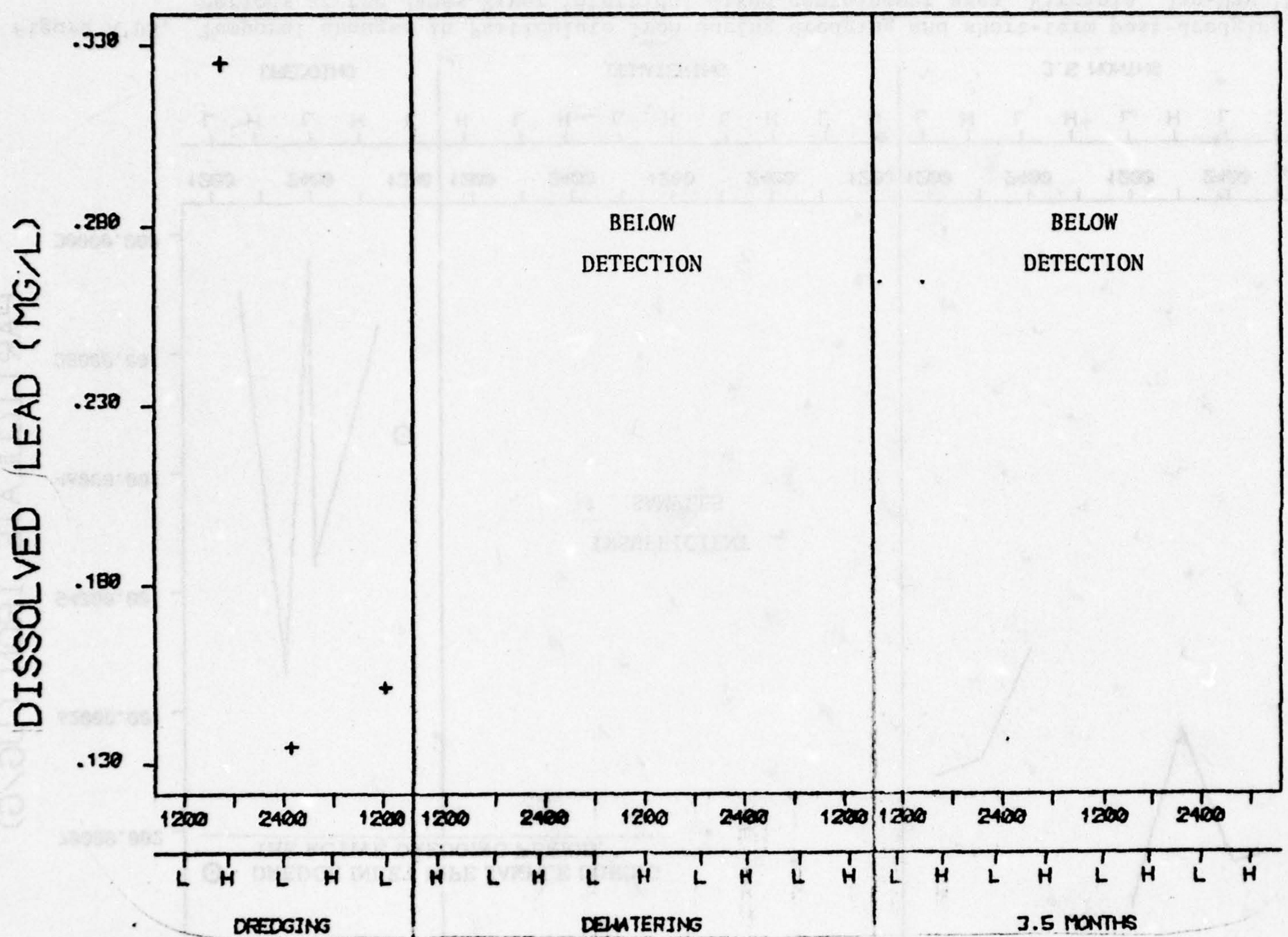

Figure A'96. Temporal changes in Dissolved Lead during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, Jan-May 1975.

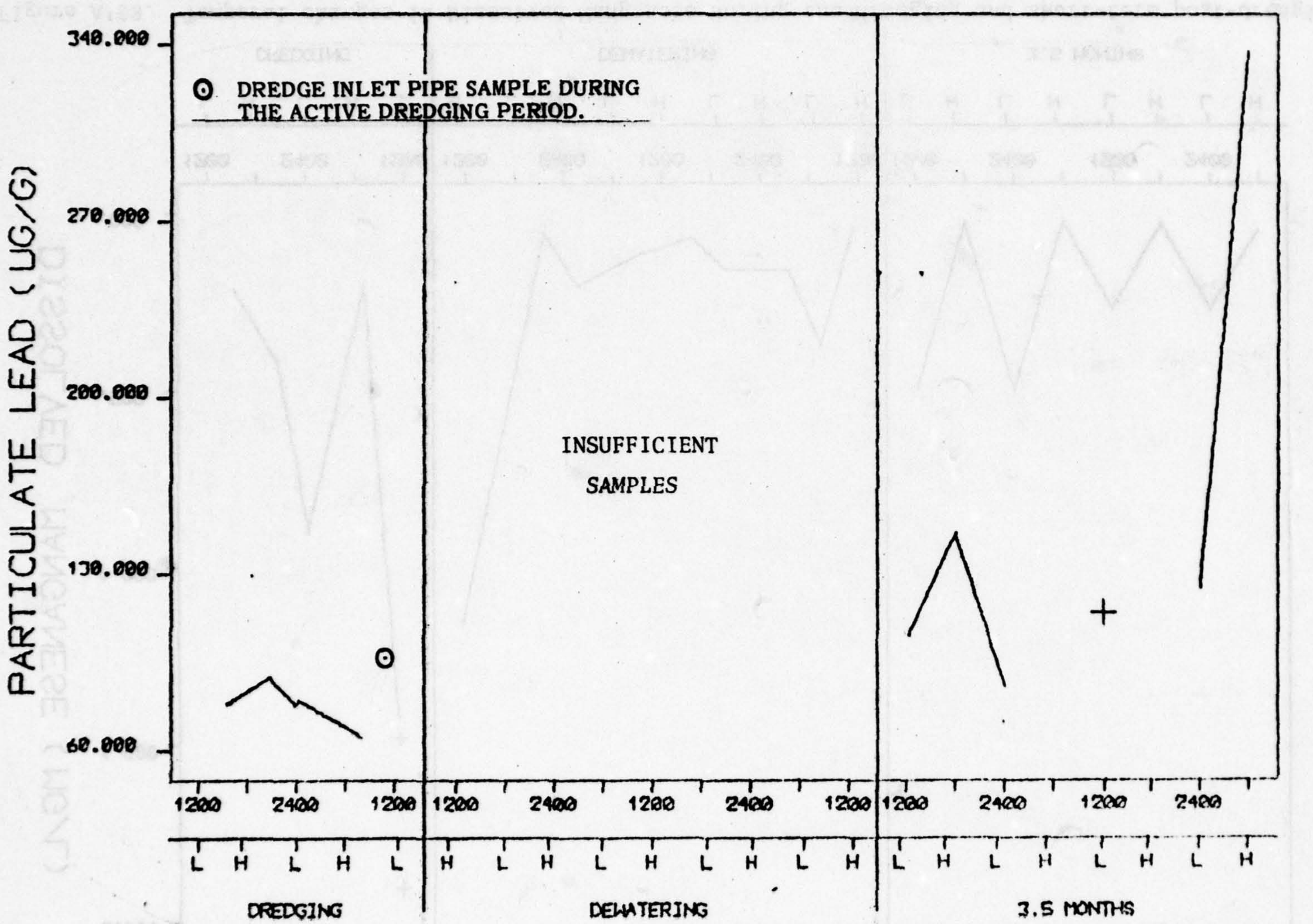

Figure A'97. Temporal changes in Particulate Lead during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, Jan-May 1975.

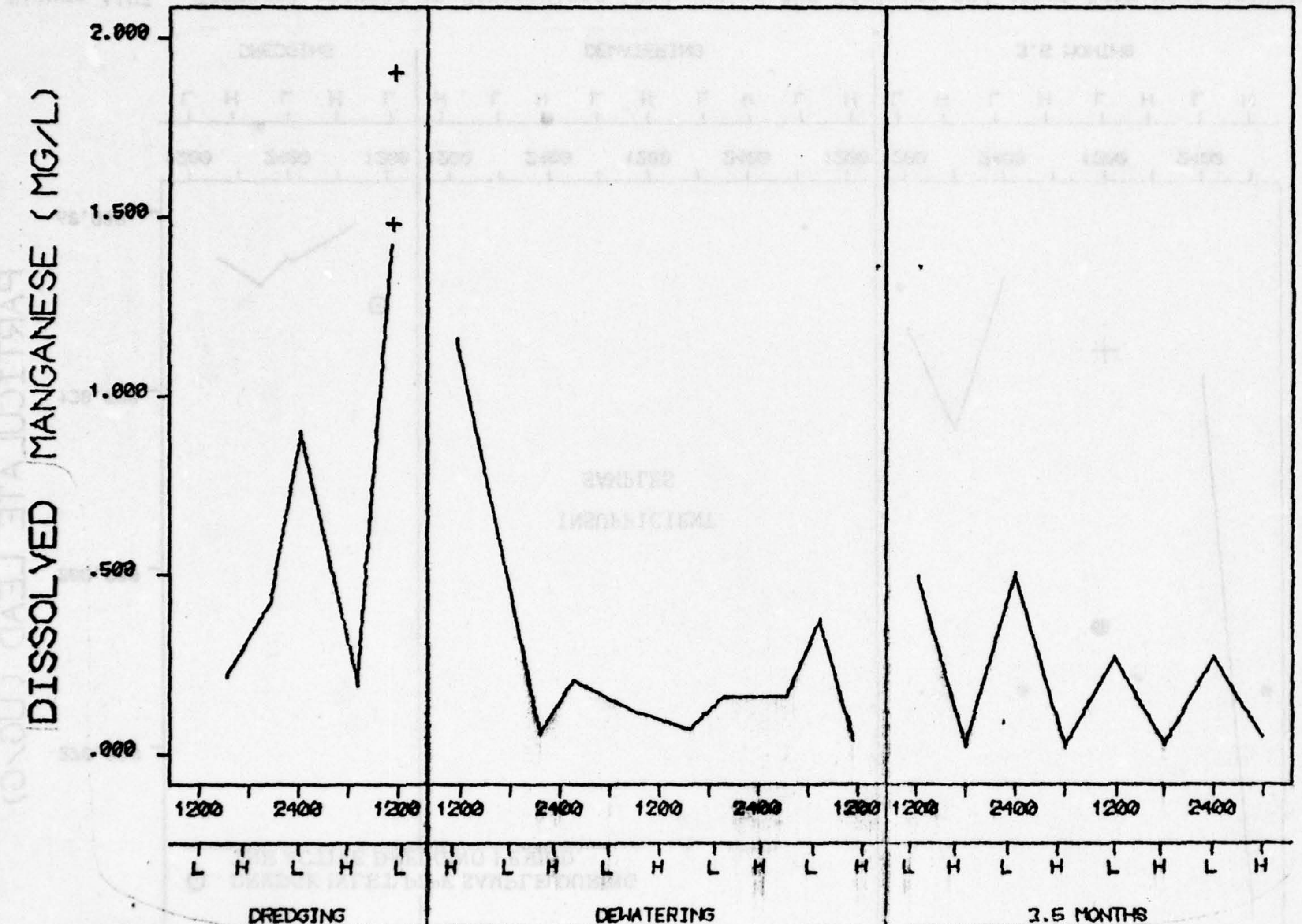

Figure A'98. Temporal changes in Dissolved Manganese during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, Jan-May 1975 (+ = samples collected 15 minutes apart).

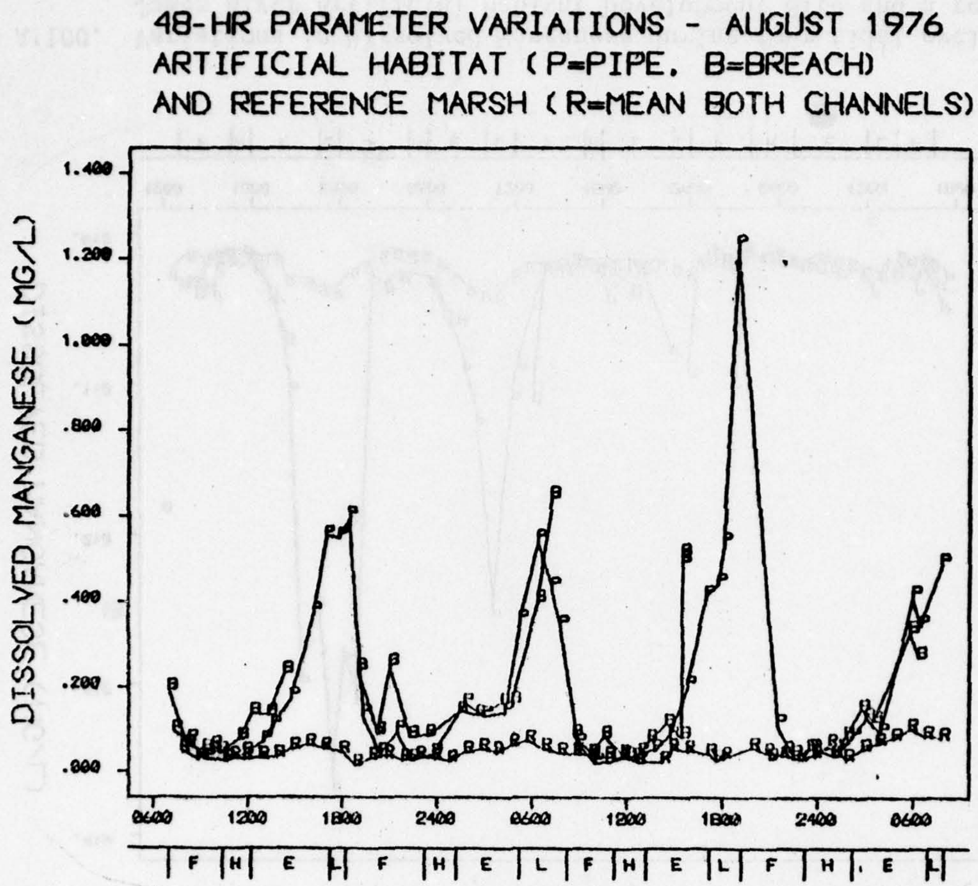

Figure A'99. Variations in Dissolved Manganese during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh.

54-HR PARAMETER VARIATIONS - JANUARY 1977
ARTIFICIAL HABITAT (P=PIPE. B=BREACH)
AND REFERENCE MARSH (R=MEAN BOTH CHANNELS)

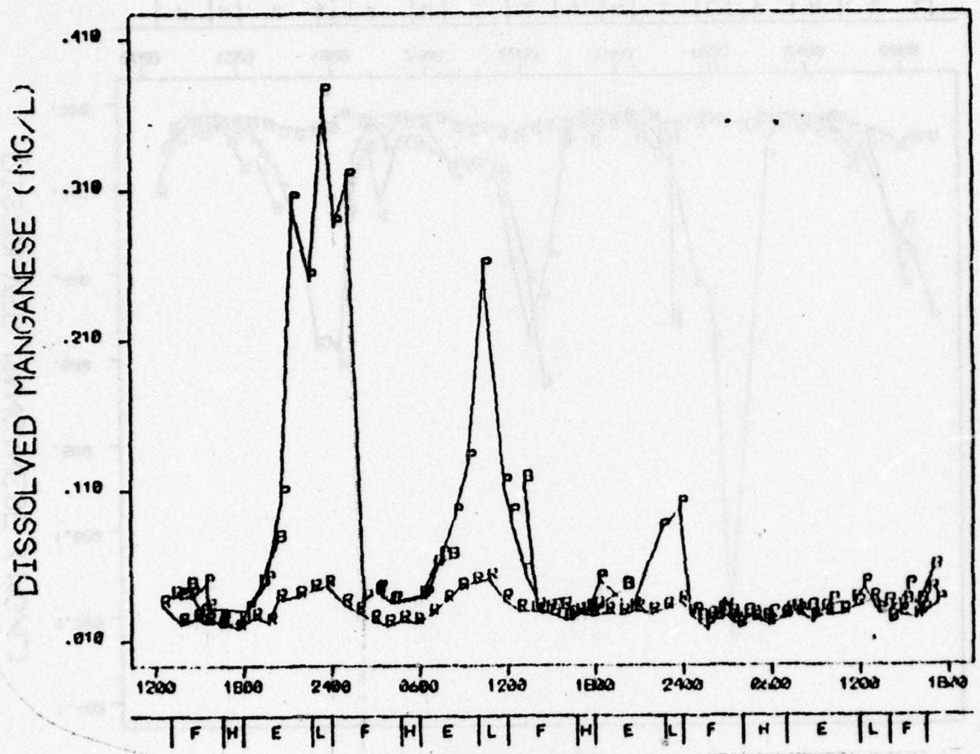

Figure A'100. Variations in Dissolved Manganese during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh.

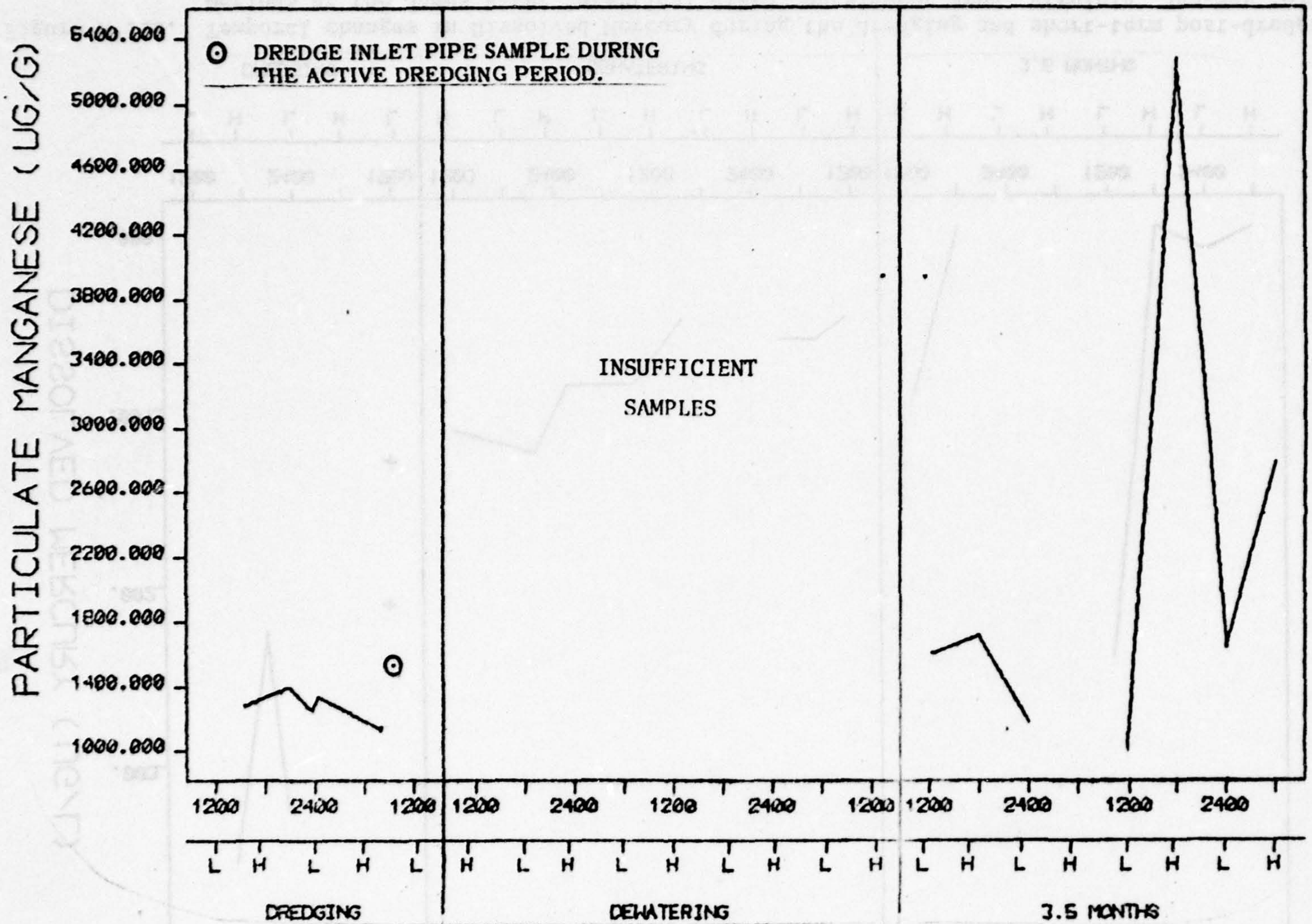

Figure A'101. Temporal changes in Particulate Manganese during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, Jan-May 1975.

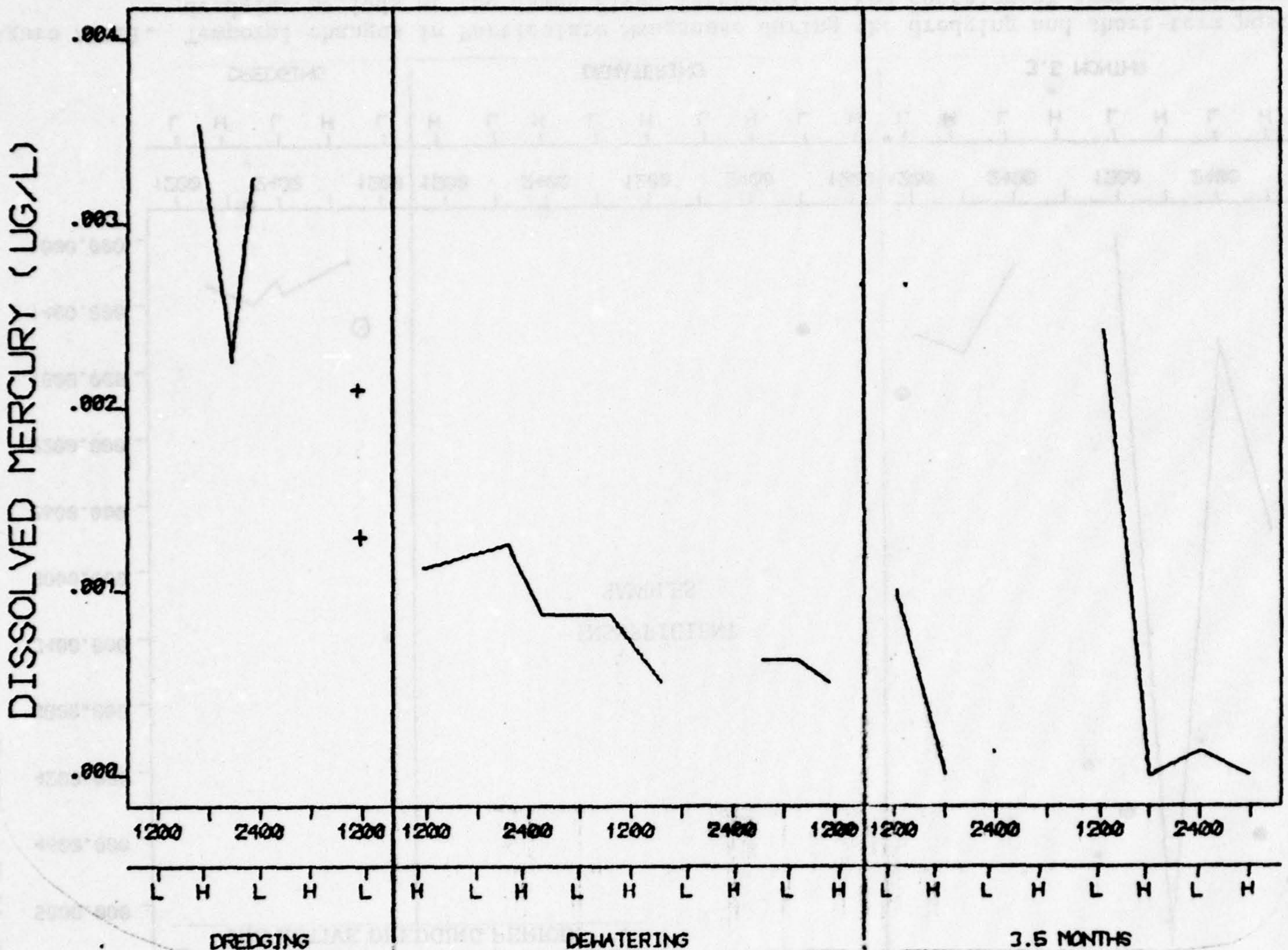

Figure A'102. Temporal changes in Dissolved Mercury during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, Jan-May 1975 (+ = samples collected 15 minutes apart).

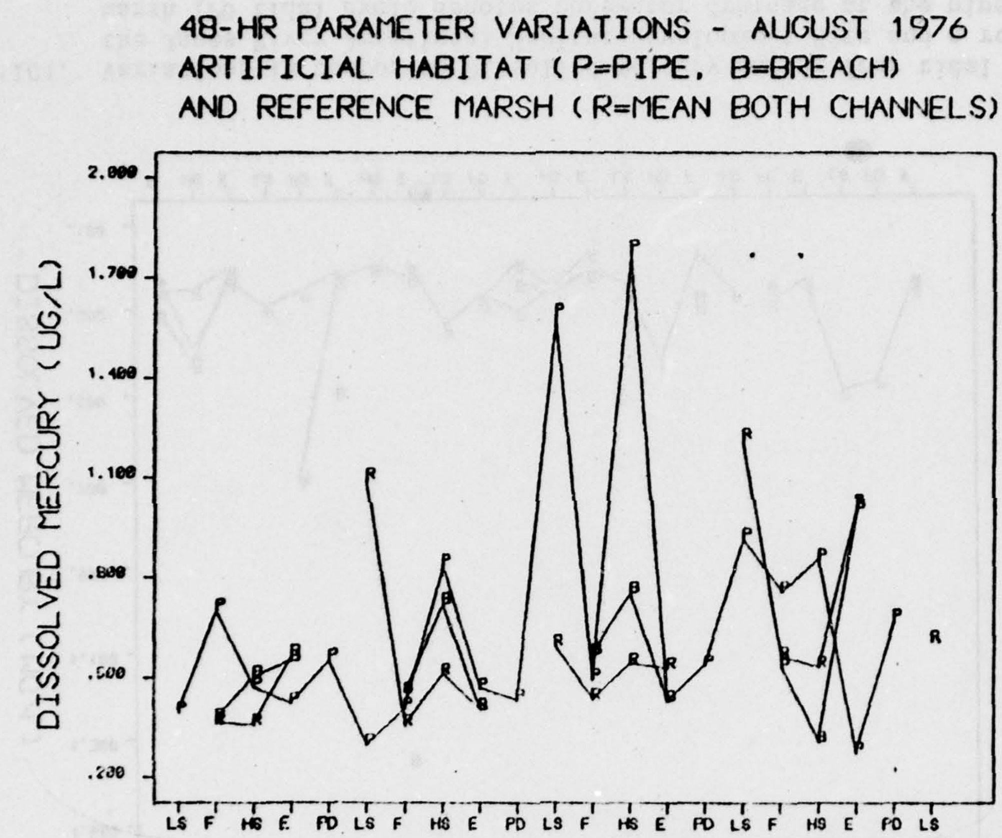

Figure A'105. Variations in composite Dissolved Mercury during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (PD tidal cycle denotes porewater drainage at the pipe).

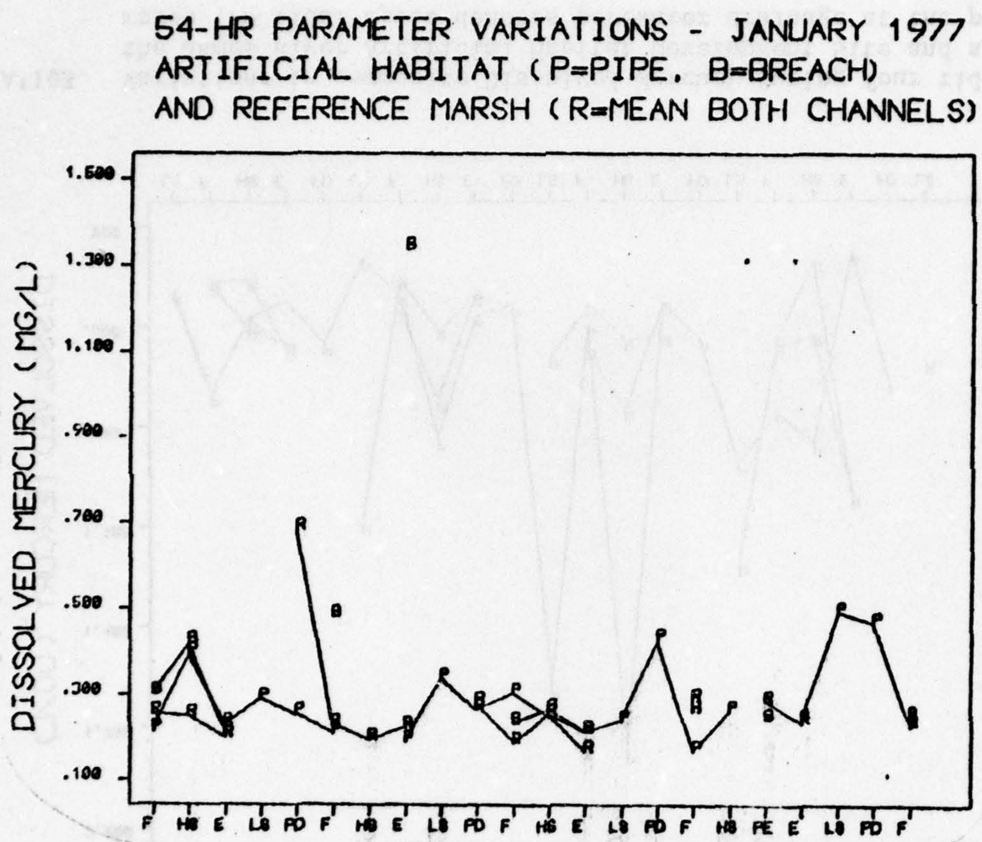

Figure A'104. Variations in composite Dissolved Mercury during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (PD tidal cycle denotes porewater drainage at the pipe).

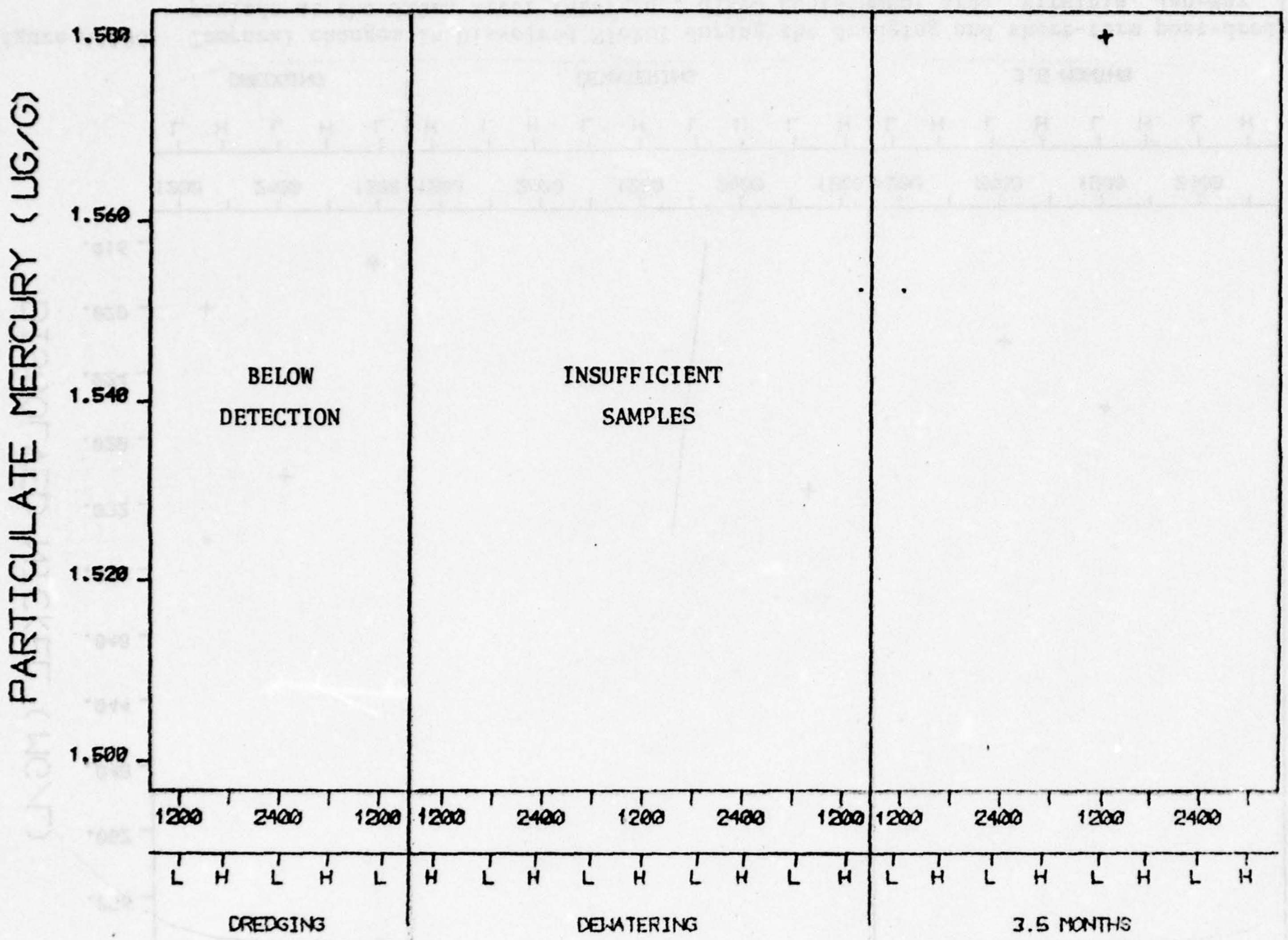

Figure A'105. Temporal changes in Particulate Mercury during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, Jan-May 1975.

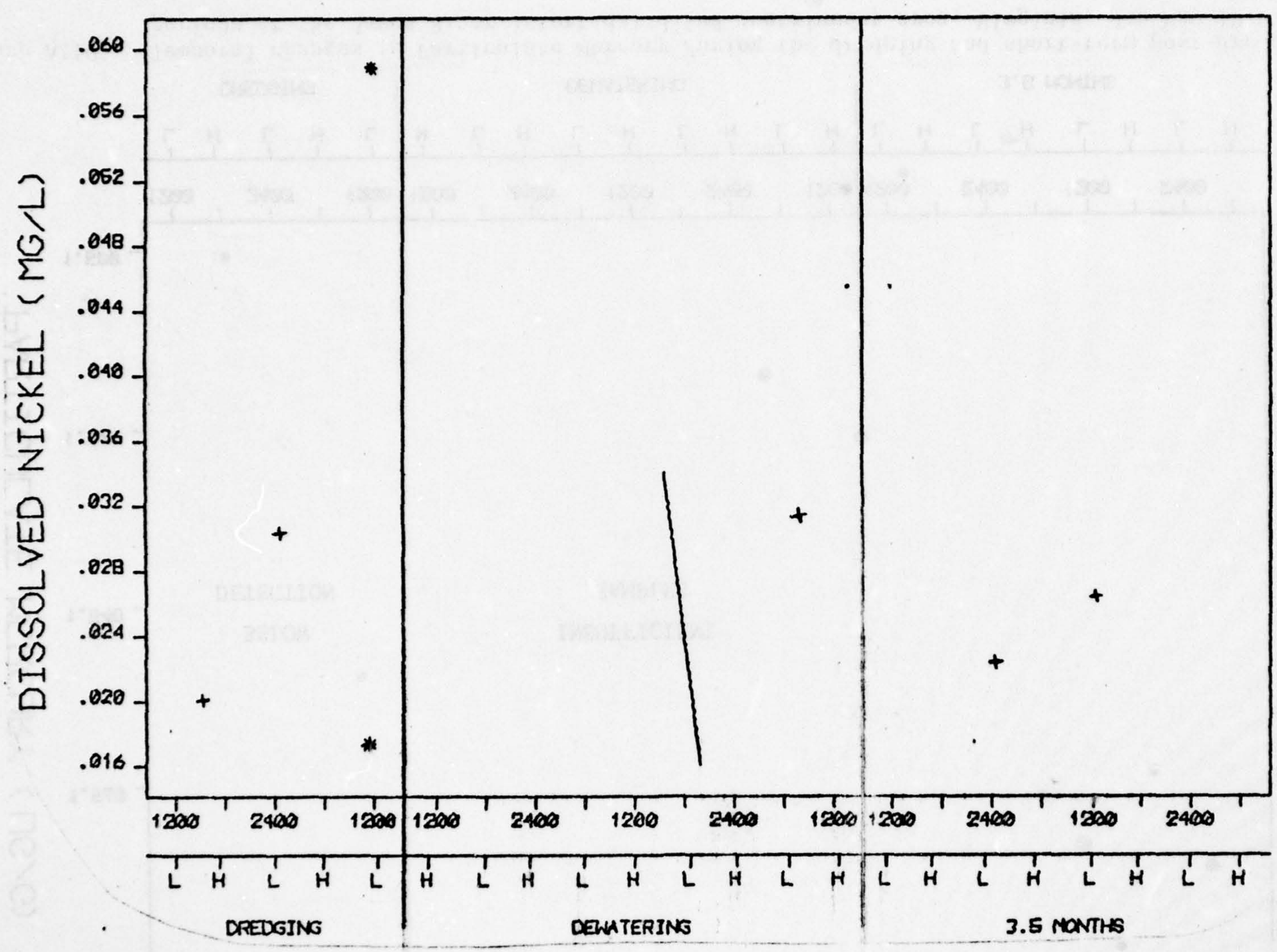

Figure A'106, Temporal changes in Dissolved Nickel during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, Jan-May, 1975 (* = samples collected 15 minutes apart during the dredging period).

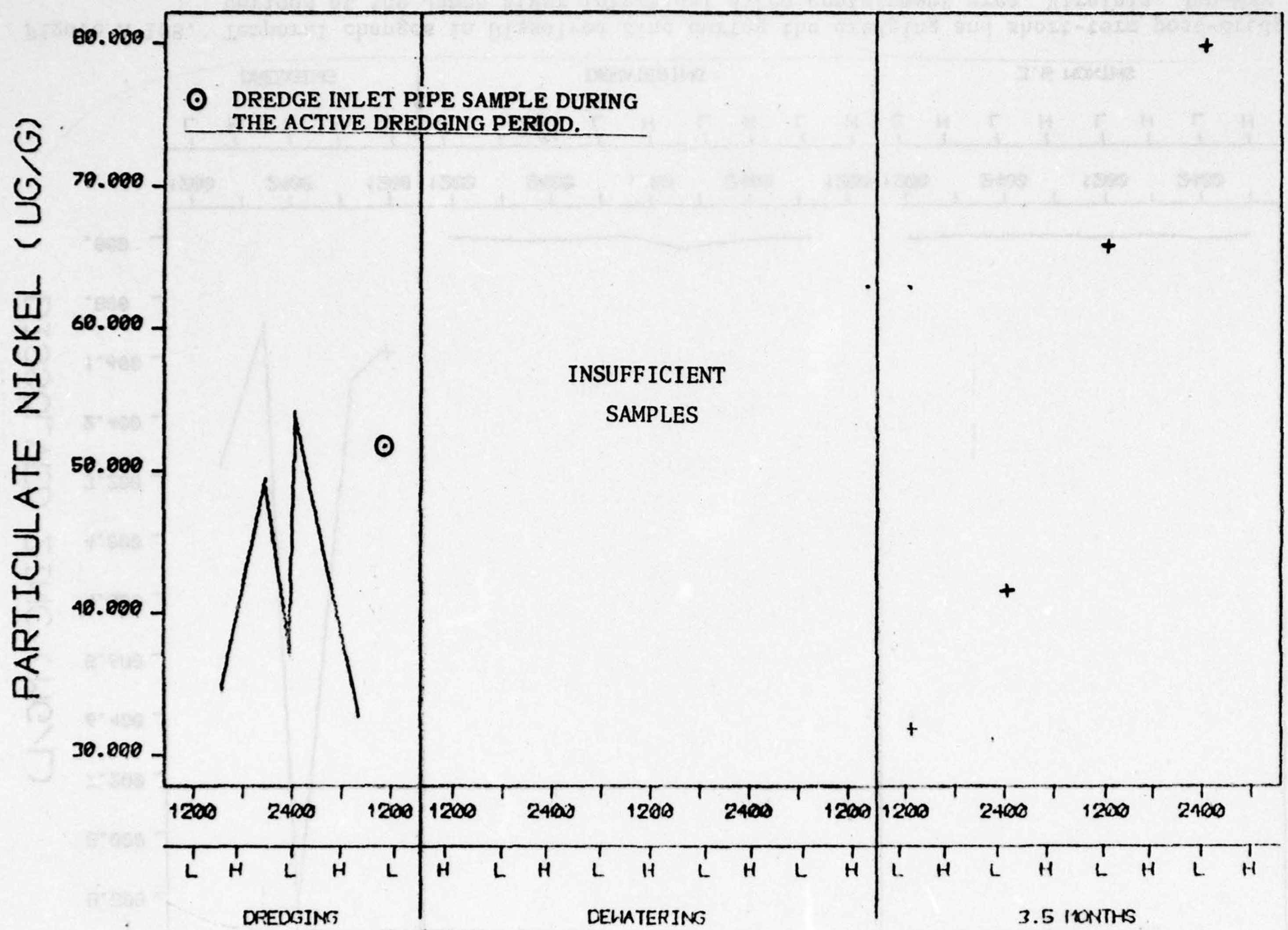

Figure A'107. Temporal changes in Particulate Nickel during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, Jan-May 1975.

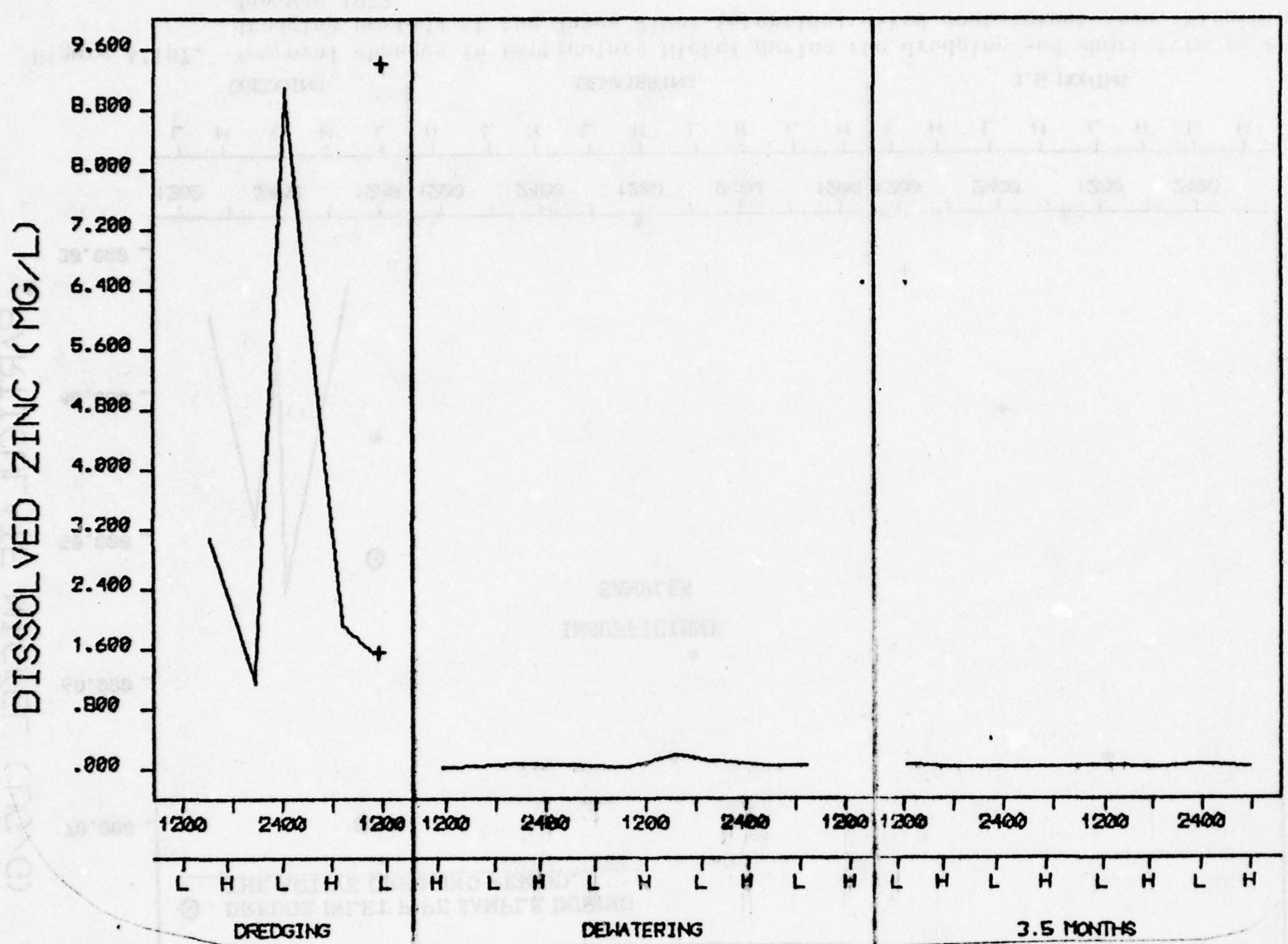

Figure A'108. Temporal changes in Dissolved Zinc during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, Jan-May 1975 (+ = samples collected 15 minutes apart).

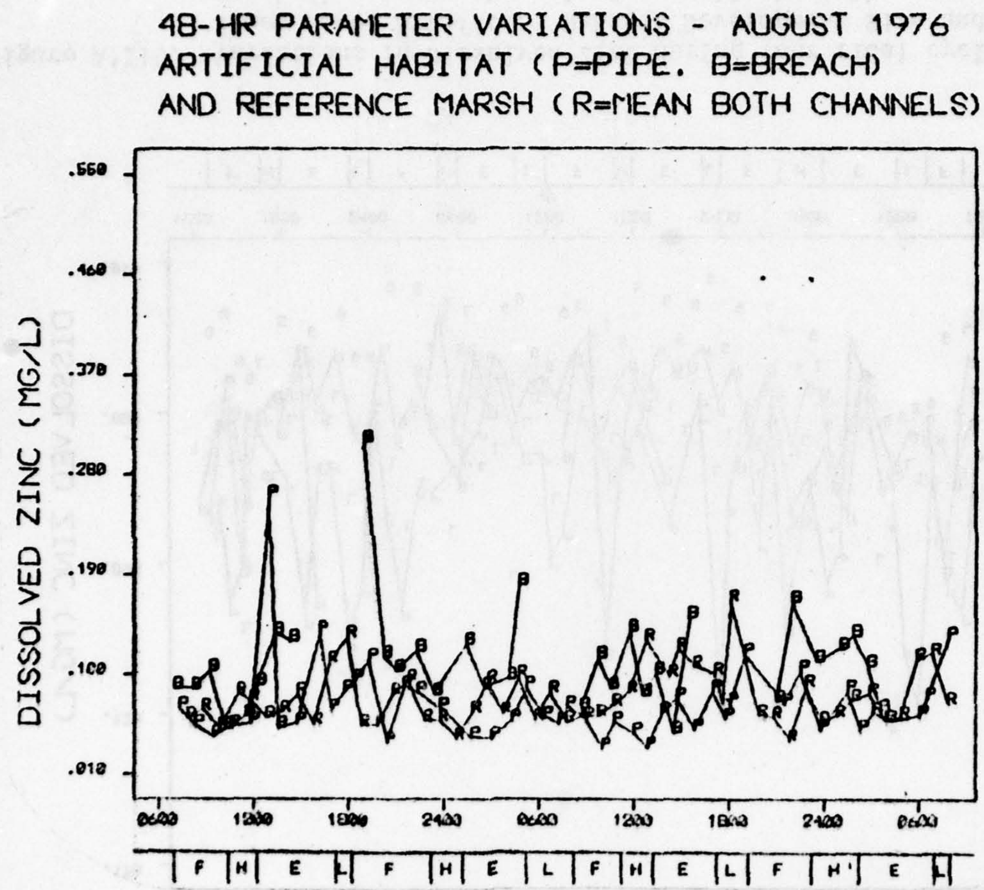

Figure A'109. Variations in Dissolved Zinc during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh.

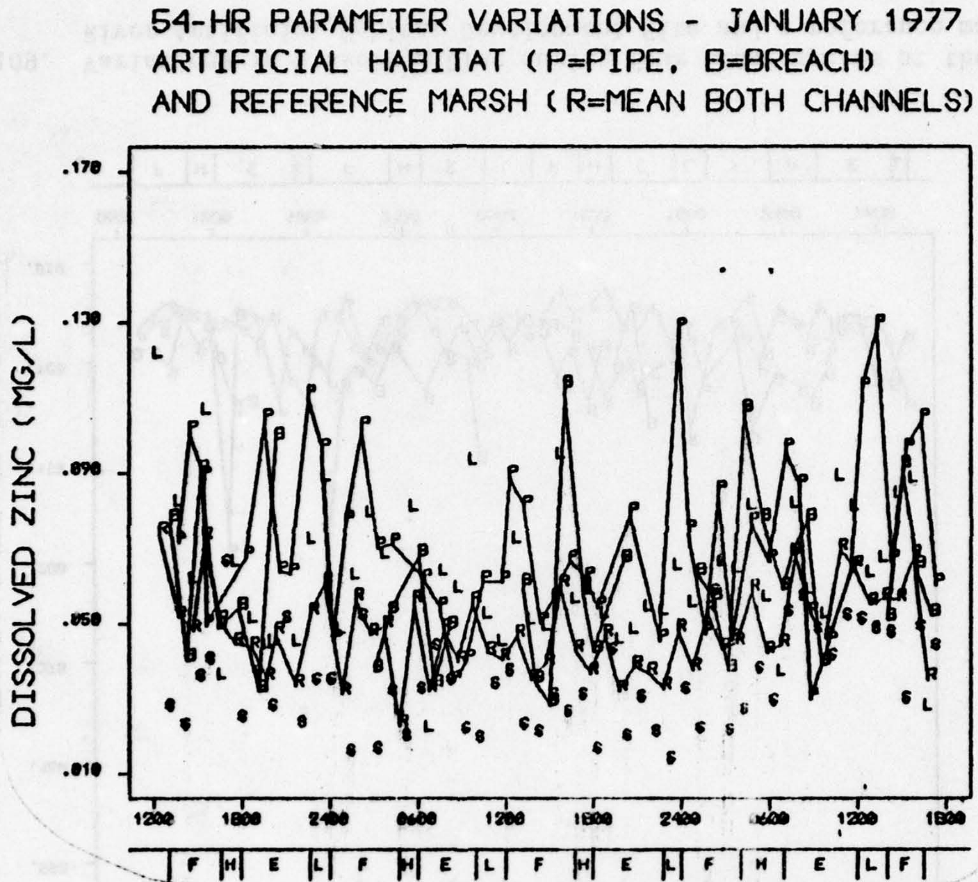

Figure A'110. Variations in Dissolved Zinc during four tidal cycles at the James River Artificial Habitat Development Site and a reference marsh (L = large channel, S = small channel).

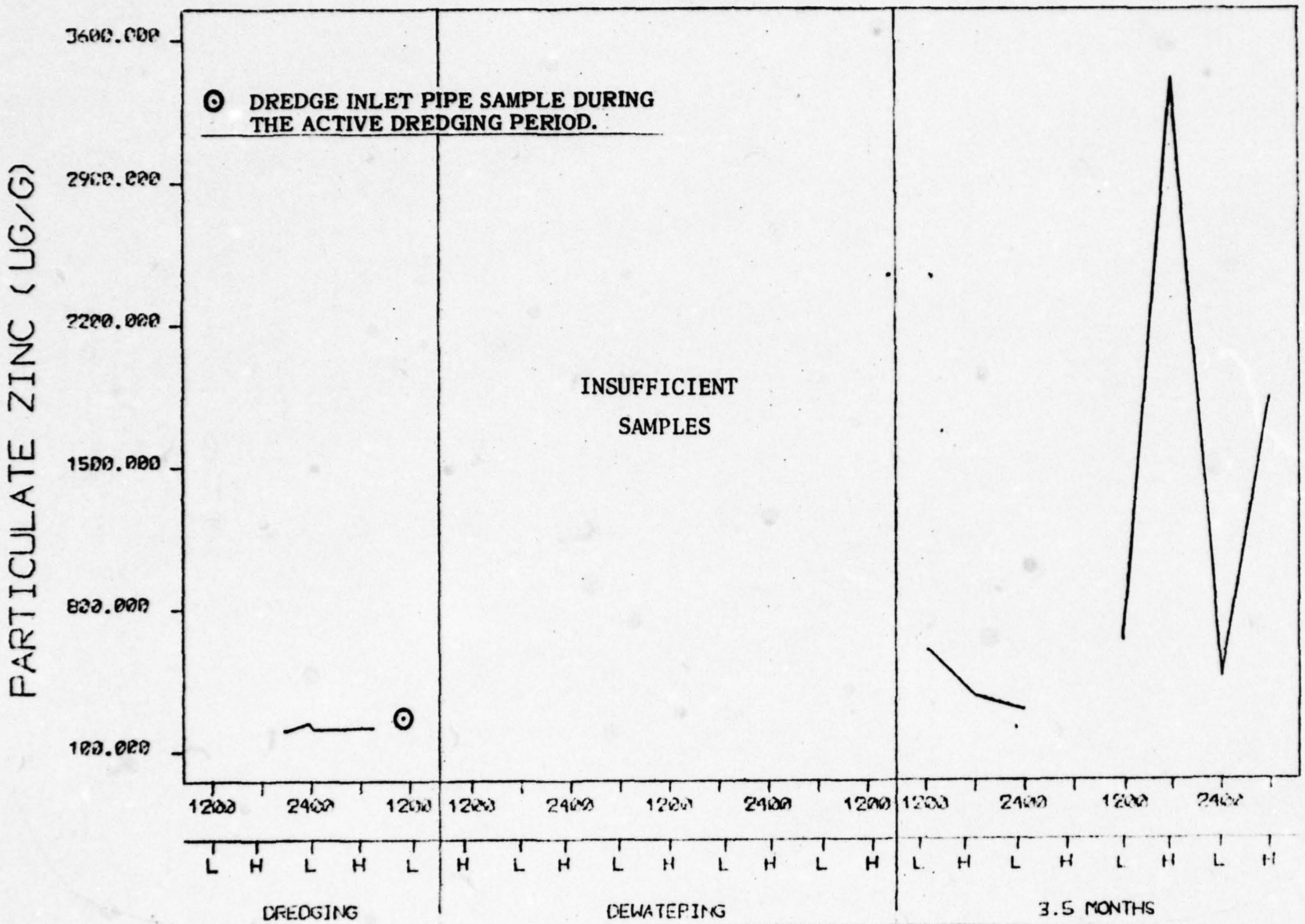

Figure A'111. Temporal changes in Particulate Zinc during the dredging and short-term post-dredging periods at the James River intertidal diked containment area, Virginia, Jan-May 1975.

APPENDIX B'

TABLES B'1-B'88

DATA TABULATION

Table B'1

Measurements for Percent Water, Temperature, pH, pS, Total H_2S, Eh, and Volatile Solids for 10 Cores from the James River near Windmill Point (See Figure 5)

Core Number	Core Section and Depth Interval* (cm)	Water** (%)	Depth† (cm)	Water† (cm)	Temp† (°C)	pH†	pS† †† (mV)	H_2S† (mg/1)	Eh†,‡ (mV)	Depth Interval (cm)	Loss at 100°C‡‡ (%)	Loss at 540°C‡‡ (%)	Loss at 1000°C‡‡ (%)
2	U (13-25)	52.4	25	56.3	14	6.48	-026	3.09	+003	25 - 35	1.30	13.87	--
	L (78-89)	50.0	85	46.0	18	6.54	-013	2.36	-081	78 - 89	1.62	14.58	--
3	U (13-25)	56.9	20	53.0	15	6.56	-032	2.76	000	35 - 45	1.56	13.30	1.93
	L (80-90)	49.7	90	51.4	15	6.44	-035	3.02	+014	80 - 90	2.12	18.98	2.88
4	U (00-13)	59.9	06	62.2	13	--	-003	2.78	-016	13 - 26	0.82	11.25	1.69
	L (78-88)	46.6	66	49.8	16	6.75	-020	7.98	-159	78 - 88	1.63	15.85	2.03
5	U (01-12)	57.7	20	58.5	9	7.04	-013	--	-008	01 - 12	1.85	14.37	1.18
	L (75-84)	45.9	90	49.8	11	6.93	-012	--	+044	75 - 84	2.08	18.35	1.69
6	U (02-13)	58.0	12	53.9	10	7.09	-014	2.27	+044	02 - 13	2.52	14.72	--
	L (59-68)	47.0	72	44.6	12	6.83	-018	3.49	+024	77 - 86	2.19	14.87	--
7	U (11-30)	53.0	07	55.7	15	6.98	+029	2.24	-034	11 - 30	1.14	12.60	--
	L (76-95)	49.0	77	43.0	17	6.58	-017	3.03	-081	95 - 97	1.97	14.87	--
8	U (01-11)	59.4	14	58.3	14	6.74	-023	--	-019	01 - 11	1.32	13.35	2.53
	L (77-86)	48.6	84	50.2	17	6.50	-038	3.60	-026	77 - 86	1.79	14.05	2.16
9	U (00-11)	57.7	13	52.9	12	6.53	-016	2.77	+008	00 - 11	1.45	14.01	--
	U (---)	--	33	46.5	13	6.55	-031	5.08	+011	---	--	---	--
	L (---)	--	63	44.6	13	6.45	-014	3.80	-021	66 - 77	0.89	12.40	--
	L (77-86)	42.8	93	36.7	13	6.36	-043	5.09	+019	---	--	---	--
10	U (02-11)	46.0	30	44.6	8	6.84	-030	1.94	-064	02 - 11	1.86	16.65	--
	L (70-80)	58.1	80	--	9	6.82	-026	2.34	+014	41 - 50	1.97	13.41	--
12	U (11-30)	59.4	16	59.9	17	6.90	-038	3.13	-103	02 - 11	1.35	13.83	--
	L (58-83)	52.8	76	48.7	18	6.70	-008	5.50	-121	68 - 83	1.76	15.35	--

* From measurements of extruded cores (under nitrogen atmosphere) in the laboratory after transport by truck from Hopewell to Norfolk, Virginia. This depth interval was used only for the percent water measurements tabulated in column 4

** Sediment collected from depth interval in column 3 was analyzed by freeze-drying to constant weight

† Sedimentary parameters listed in columns 6-11 were measured at this depth or processed from subsamples collected with special 50 cc syringes (% water, total H_2S). Water content was determined by drying at 60°C to constant weight (column 6), this measurement was used for calculating interstitial H_2S concentration. Temperature, pH, pS, and Eh were measured (under nitrogen), through predrilled holes, immediately after recovery of the core

†† Potential of an Orion silver/silver-sulfide specific ion electrode. Values were corrected for the potential of the saturated calomel electrode

‡ Average for two platinum electrodes inserted through the same predrilled hole in the core liner. Both were connected to a common reference electrode, and values were corrected for the potential of the SCE

‡‡ Percent weight loss at specified temperatures from constant weight at 60°C (dried for 72 hrs)

Table B'2

Dissolved Interstitial Nutrients (mg/l) and Total Sediment Nitrogen and Phosphorus (μg/g; Dry Weight) for the Upper (U) and Lower (L) Portions of 10 Cores from the James River Channel near Windmill Point, January 1975, N = Dissolved Nutrients; B = Total Nitrogen (Column 6) and Total Phosphorus (Column 5). TDP and TDN Are Interstitial Dissolved Total Phosphorus and Dissolved Total Nitrogen from Acid-Digested Samples (for Code N Only)

Core Number	Section*	Depth (cm)	Code	TDP or TP	TDN or TKN	NO_3	NO_2	PO_4	NH_4**	NH_4
2	U	00-45	N	0.294	59.8	0.038	0.004	0.162	57.6	
	L	45-89	N	0.328	59.7	0.036	0.007	0.252	63.8	
	U	13-25	N							43.9
	U	35-45	N							71.3
	L	66-78	N							65.2
	L	78-89	N							62.3
	U	13-25	B	720	4580					
	U	35-43	B	660	3990					
	L	54-66	B	682	5340					
	L	78-89	B	709	5070					
3	U	00-35	N	0.340	106	0.068	0.002	0.093	67.7	
	L	45-90	N	0.784	83.1	0.078	0.010	0.527	72.7	
	L	45-58	N							54.4
	U	25-35	N							67.7
	L	80-90	N							91.0
	U	01-13	B	693	4350					
	U	35-45	B	701	4800					
	L	45-58	B	675	3630					
	L	80-90	B	714	4350					
4	U	00-45	N	0.304	63.4	0.049	0.005	0.178	62.0	
	L	45-88	N	0.368	72.2	0.053	0.004	0.132	72.0	
	U	13-26	N							54.2
	U	36-45	N							69.7
	L	45-55	N							66.1
	L	78-88	N							77.9
	U	13-26	B	712	4350					
	U	36-45	B	690	4350					
	L	45-55	B	720	4170					
	L	78-88	B	504	4090					

(continued)

* U = upper section of core, L = lower section of core

** NH_4 in column 10 is the statistical mean from actual values listed in column 11

Table B'2 (Continued)

Core Number	Section*	Depth (cm)	Code	TDP or TP	TDN or TKN	NO_3	NO_2	PO_4	NH_4**	NH_4
5	U	00-42	N	0.544	69.2	0.059	0.010	0.417	67.8	
	L	42-84	N	0.472	84.5	0.073	0.011		0.446	73.5
	U	12-23	N							64.4
	U	32-42	N							69.6
	L	53-65	N							78.3
	L	75-84	N							68.7
	U	01-12	B	362	5400					
	U	32-42	B	668	4350					
	L	42-53	B	709	4170					
	L	75-84	B	689	4800					
6	U	00-41	N	0.240	70.4	0.059	0.002	0.113	63.5	
	L	41-86	N	0.624	86.4	0.040	0.003	0.457	79.2	
	U	13-22	N							48.6
	U	31-41	N							78.3
	L	68-77	N							77.3
	L	77-86	N							81.1
	U	02-13	B	681	3990					
	U	31-41	B	720	4390					
	L	50-59	B	734	5080					
	L	77-86	B	665	5340					
7	U	00-58	N	0.183	77.6	0.072	0.006	0.072	66.3	
	L	58-76	N	0.368	73.9	0.109	0.006	0.187	64.7	
	U	30-48	N							63.9
	U	39-58	N							64.7
	L	48-58	N							70.2
	L	58-76	N							64.7
	U	11-30	B	671	5640					
	L	53-71	B	734	4980					
	L	95-97	B	456	4350					
8	U	00-41	N	0.584	47.7	0.040	0.010	0.102	50.6	
	L	41-86	N	0.608	59.5	0.044	0.008	0.533	56.7	
	U	01-11	N							37.4
	U	11-21	N							52.5
	U	31-41	N							61.9
	L	41-50	N							57.8
	L	50-59	N							44.9
	L	59-68	N							52.1
	L	68-77	N							61.8
	L	77-86	N							68.5
	U	01-11	B	706	4350					
	U	31-41	B	652	2660					
	L	41-50	B	716	5730					
	L	77-86	B	708	6360					

(continued)

* U = upper section of core, L = lower section of core

** NH_4 in column 10 is the statistical mean from actual values listed in column 11

Table B'2 (Concluded)

Core Number	Section*	Depth (cm)	Code	TDP or TP	TDN or TKN	NO_3	NO_2	PO_4	NH_4**	NH_4
9	U	00-43	N	0.416	63.4	0.054	0.004	0.220	43.9	
	L	43-86	N	0.592	77.8	0.050	0.003	0.298	71.8	
	U	25-34	N							43.9
	L	43-50	N							67.3
	L	50-59	N							77.2
	L	59-68	N							76.1
	L	77-86	N							66.6
	U	00-11	B	690	4710					
	U	34-43	B	669	4800					
	L	43-50	B	701	4800					
	L	68-77	B	706	4800					
10	U	00-41	N	0.512	54.6	0.070	0.004	0.260	36.0	
	L	41-80	N	0.560	67.2	0.063	0.006	0.322	51.7	
	U	11-21	N							36.0
	L	50-60	N							55.8
	L	70-80	N							47.6
	U	02-11	B	619	4350					
	U	31-41	B	179	4350					
	L	41-50	B	704	4170					
	L	70-80	B	712	4150					
12	U	00-40	N	0.440	38.7	0.044	0.008	0.215	61.1	
	L	40-83	N	0.568	79.2	0.064	0.013	0.056	74.4	
	U	02-20	N							51.1
	U	20-40	N							71.1
	L	40-58	N							76.7
	L	58-83	N							72.0
	U	02-11	B	622	5660					
	U	20-40	B	683	8500					
	L	40-50	B	703	4500					
	L	68-83	B	761	3990					

* U = upper section of core, L = lower section of core

** NH_4 in column 10 is the statistical mean from actual values listed in column 11

Table B'3

Dissolved Interstitial Metals (mg/l) and Bulk Sediment Metals (µg/g; Dry Weight) for the Upper (U) and Lower (L) Portions of 10 Cores from the James River Channel near Windmill Point, January 1975. M = Dissolved Interstitial Metals; A = Total Sediment Metals. Missing Data Were Below the Detection Limit for each Specific Element. Depth Is Shown as an Interval (0 cm = Surface)

Core Number	Section	Depth (cm)	Code	Ca*	Cd	Cu	Fe	Hg	Mn	Ni	Pb	Zn
2	U	13-25	M	240.9	0.010	0.011	61.31	0.0074	12.37	0.044	0.063	
	U	35-45	M	245.3	0.012	0.006	55.01		7.424	0.076	0.053	
	L	45-54	M	256.1	0.012	0.009	73.91		5.074	0.036	0.133	
	L	54-66	M	230.9	0.010	0.007	56.21		4.430	0.061	0.072	0.116
	L	66-78	M	227.1	0.011	0.008	59.32		6.629	0.001	0.072	0.023
	L	78-89	M	224.8	0.011	0.008	71.72	0.0086	1.350	0.057	0.072	0.031
	U	13-25	A	4140	0.68	41.32	39160	0.650	1268	36.03	57.05	227.1
	L	78-89	A	4570	1.11	49.89	49310	0.556	1108	32.09	61.55	267.8
3	U	13-25	M	235.4	0.010	0.006	60.46		4.270	0.050	0.116	0.263
	U	25-35	M	178.3	0.020	0.027	142.4	0.0057	8.713	0.053	0.060	0.453
	L	45-58	M	230.9	0.012	0.010	31.08		6.060	0.048	0.063	0.361
	L	80-90	M	197.8	0.014	0.021	61.94	0.0005	2.951	0.079	0.051	2.268
	U	13-25	A	3740	1.62	40.43	35590	0.500	936.5	25.20	60.58	213.2
	L	80-90	A	3560	1.23	39.42	37760	0.397	904.2	24.10	63.29	203.3
4	U	00-13	M	223.9	0.012		44.93	0.0030	12.62	0.058	0.063	
	U	13-26	M	188.1	0.007		54.34		11.70	0.056		0.296
	U	36-45	M	249.4	0.012	0.014	49.93		6.173	0.062	0.094	1.220
	L	45-55	M	265.8	0.013		60.08	0.0026	7.235	0.062	0.080	0.005
	L	68-78	M	134.0	0.012	0.046	41.90		3.062	0.021	0.050	3.561
	U	00-13	A	4020	1.43	50.25	51120	0.436	1194	33.07	77.36	276.5
	L	78-88	A	3490	1.21	47.94	41380	0.622	918.4	29.33	61.48	230.7

(continued)

* Total sediment calcium was analyzed from a different subsample for each section of the cores

Table B'3 (Continued)

Core Number	Section	Depth (cm)	Code	Ca*	Cd	Cu	Fe	Hg	Mn	Ni	Pb	Zn
5	U	01-12	M	218.0	0.009	0.006	68.24	0.0025	16.95	0.065	0.080	0.018
	U	32-42	M	251.8	0.009	0.009	56.83		5.756	0.071	0.063	0.046
	L	42-53	M	477.8	0.011	0.008	82.99		12.61	0.068	0.080	0.007
	L	65-75	M	228.9	0.011	0.008	88.61	0.0035	5.756	0.074		
	U	01-12	A	3810	1.14	44.56	39520	0.428	909.2	19.30	62.81	214.3
	U (L)**	32-42	A	4180 (80)	1.09	49.60	45510	0.462	1016	33.68	58.89	243.1
6	U	02-13	M	224.7	0.008	0.008	62.52		2.333	0.053	0.077	0.048
	U	31-41	M	194.3	0.004	0.012	57.53	0.0005	6.363	0.098	0.094	0.009
	L	50-59	M	232.5	0.010	0.013	146.1	0.0031	6.363	0.003	0.107	0.015
	L	77-86	M	145.9	0.007	0.007	31.44		1.659	0.032	0.055	0.018
	U	02-13	A	4310	1.11	53.59	46980	0.534	1109	30.55	61.58	115.2
	U (L)**	31-41	A	4640 (64)	0.88	44.37	37850	0.533	962.8	25.32	56.75	217.1
7	U	11-30	M	164.8	0.008	0.006	40.63	0.0021	11.41	0.050	0.063	0.407
	U	30-39	M	272.4	0.012	0.010	50.60		9.206	0.061	0.080	0.079
	L	71-86	M	198.1	0.008	0.006	31.84	0.027	5.004	0.044	0.063	0.013
	U	11-30	A	4130	1.48	55.87	47810	0.720	1086	34.47	72.64	266.0
	U	11-30	A		1.40	50.32	43010		1385	48.58	70.14	297.8
	L**	86-95	A	4200 (86)	1.00	79.28	34780		1196	33.76	45.86	194.4
8	U	01-11	M	208.0	0.005	0.006	37.52	0.0048	12.51	0.051	0.063	
	U	31-41	M	233.0	0.009	0.008	69.91		8.599	0.051	0.133	
	L	41-50	M	228.6	0.009	0.006	62.44	0.0036	6.325	0.034	0.124	
	L	77-86	M	117.2	0.003		35.86		4.387	0.023		0.040
	U	01-11	A	4060	0.02	32.16	20030		929.7	33.65	39.80	168.6
	U	31-41	A		0.05	32.56	34310	0.250	972.4	34.71	40.28	178.6
	L	41-50	A		1.36	54.46	48650	0.623	1056	32.36	66.07	252.9
	L	77-86	A	3340	1.85	91.70	55000	0.021	1345	37.25	94.13	317.2

(continued)

* Total sediment calcium was analyzed from a different subsample for each section of the cores

** The depth interval for total calcium was the same except for these samples (mean depth in cm)

Table B'3 (Concluded)

Core Number	Section	Depth (cm)	Code	Ca*	Cd	Cu	Fe	Hg	Mn	Ni	Pb	Zn
9	U	00-11	M	233.8	0.009	0.007	47.45	0.0025	15.74	0.059	0.094	0.055
	U	25-34	M	243.1	0.011		65.09	0.0018	7.576	0.032	0.085	0.18
	U	34-43	M	233.3	0.009	0.009	76.43	0.0021	7.727	0.083	0.067	
	L	50-59	M	246.9	0.012	0.013	81.47	0.0019	6.552	0.057	0.050	0.014
	L	59-68	M	247.0	0.013	0.008	60.46	0.0024	4.633	0.044	0.080	0.060
	L	77-86	M	136.9	0.005	0.006	36.90	0.0030	1.587	0.043		
	U	00-11	A	4240	1.50	41.07	37120	0.680	1136	38.49	54.31	314.2
	U	34-43	A		2.95	51.22	49210	0.611	1182	29.72	79.26	262.2
	L	50-59	A		1.89	54.88	34680		1283	41.14	71.36	268.5
	L	77-86	A	3400	2.45	49.23	33890		1203	43.26	70.12	255.8
10	U	02-11	M	127.9	0.005		31.71	0.0066	5.908	0.044	0.046	0.018
	U	31-41	M	196.6	0.008		82.73		6.704	0.053	0.063	0.005
	L	41-50	M	209.6	0.009	0.007	68.67	0.0030	5.491	0.054	0.063	0.009
	L	70-80	M	90.04	0.002	0.010	22.99		2.345	0.021	0.048	0.205
	U	02-11	A	3710	0.78	38.50	38870	0.480	870.8	24.00	57.69	205.8
	L	70-80	A	3810	0.36	24.87	19190		794.4	48.58	26.16	161.2
12	U	02-20	M	240.1	0.012	0.008	45.00	0.0022	11.50	0.050	0.096	0.116
	U	11-30	M	259.2	0.011	0.009	21.63		10.89	0.051	0.074	0.055
	U	20-40	M	163.1	0.002		2.700		0.527	0.021		0.006
	L	58-83	M	156.6	0.008	0.014	28.80	0.0026	4.051	0.047	0.080	0.869
	U	11-30	A	6500	1.10	47.70	40780	0.387	983.4	26.51	65.04	249.0
	L	58-83	A	4420	1.60	54.02	49970	0.110	1724	42.00	80.97	353.6

* Total sediment calcium was analyzed from a different subsample for each section of the cores

Table B'4

Sediment Size Parameters for 10 Cores from the James River Channel near Windmill Point

(See Figure 5)

Core Number	Core Section and Depth Interval* (cm)	Mean (ϕ)	Sorting Coefficient (ϕ)	Skewness	Kurtosis	Sand (%)	Silt (%)	Clay (%)	Modes (ϕ) 1	2	3	4
2	U (13-25)	7.34	2.85	0.295	-.231	4.93	60.53	34.54	5.13	--	--	--
	L (78-89)	7.74	3.06	0.207	-.490	6.01	52.39	41.61	4.74	--	--	--
3	U (13-25)	6.50	1.77	-.109	-.607	5.51	59.90	34.59	4.75	--	--	--
	L (80-90)	5.79	3.27	0.453	-.068	41.74	34.48	23.79	3.59	6.28	9.30	--
4	U (00-13)	7.56	3.13	0.232	-.524	3.48	55.40	41.12	4.50	6.71	8.29	--
	L (78-88)	6.65	3.45	0.361	-.476	23.59	42.65	33.76	4.49	3.53	--	--
5	U (01-12)	7.45	2.83	0.244	-.330	7.36	53.96	38.68	4.79	6.26	9.39	--
	L (75-84)	8.05	3.12	0.023	-.489	16.43	34.46	49.12	3.83	7.22	9.28	--
6	U (02-13)	7.73	2.96	0.261	-.445	4.19	56.49	39.33	4.77	6.31	--	--
	L (59-69)	7.43	3.05	0.303	-.412	5.57	60.30	34.13	4.82	--	--	--
7	U (11-30)	8.16	2.98	0.175	-.553	2.23	52.81	44.90	4.97	6.25	--	--
	L (76-95)	7.22	3.41	0.258	-.593	12.95	50.03	37.02	4.41	6.74	9.80	--
8	U (01-11)	8.04	2.68	0.191	-.321	3.09	53.97	42.95	5.40	7.58	9.18	--
	L (77-86)	8.43	2.88	0.133	-.524	2.09	49.43	48.48	4.89	6.59	--	--
9	U (00-11)	8.10	3.19	0.134	-.652	2.82	48.07	49.11	4.73	8.79	--	--
	L (77-86)	7.69	3.09	0.252	-.519	4.79	56.23	39.98	4.84	--	--	--
10	U (02-11)	7.93	3.08	0.196	-.557	3.29	54.20	42.51	4.68	6.33	--	--
	L (70-80)	5.50	3.77	0.268	-.361	42.88	31.67	25.44	1.62	3.37	5.86	9.29
12	U (11-20)	9.50	3.52	-.362	-.458	14.79	12.42	72.79	3.69	11.0	--	--
	L (58-83)	10.21	2.89	-.390	-.229	2.28	22.77	74.95	5.63	7.84	12.5	--

* Depths measured from top of sediment in cores; U = upper section of cores, L = lower section of cores

Table B'5

Mineral Percentages of Less Than 2-Micron Size Fraction for 10 Cores Collected from the James River Channel near Windmill Point (See Figure 5)

Core Number	Core Section and Depth Interval* (cm)	Illite (%)	Chlorite (%)	Mixed-Layered Illite-Chlorite (%)	Vermiculite (%)	Smectite (%)	Kaolinite
2	U (13-25)	45	24	15	7	7	3
	L (78-89)	47	17	12	12	8	4
3	U (13-25)	38	14	24	15	8	2
	L (80-90)	41	23	8	4	16	6
4	U (00-15)	46	5	12	14	7	4
	L (78-88)	45	32	9	3	7	3
5	U (01-12)	39	25	17	6	8	4
	L (75-84)	44	26	7	8	7	5
6	U (02-13)	43	29	7	12	6	3
	L (59-68)	35	21	17	18	5	5
7	U (11-30)	33	28	10	15	8	6
	L (76-95)	46	21	12	2	5	12
8	U (01-11)	39	16	10	16	8	10
	L (77-86)	41	14	14	16	8	8
9	U (00-11)	41	29	11	9	9	1
	L (77-86)	33	13	12	20	14	7
10	U (02-11)	40	32	9	10	8	2
	L (70-80)	44	25	13	9	7	2
12	U (11-30)	43	36	6	6	5	3
	L (58-83)	40	29	15	8	9	0

* Depths measured from top of sediment in cores; U = upper section of cores, L = lower section of cores

Table B'6

Mineral Percentages of the Silt Fraction (2 - 62 μm) for 10 Cores Collected from the James River Channel near Windmill Point (See Figure 5)

Core* Number	Quartz (%)	K-feldspar (%)	Plagioclase Feldspar	Muscovite Mica	Amphibole
2 U	41	9	10	7	Tr**
L	60	17	13	9	Tr
3 U	70	12	11	8	Tr
L	58	17	16	8	Tr
4 U	49	21	14	14	3
L	59	18	12	11	Tr
5 U	61	12	11	13	3
L	67	18	10	10	Tr
6 U	50	22	13	15	Tr
L	60	17	15	8	Tr
7 U	49	20	20	12	Tr
L	60	18	15	7	Tr
8 U	56	19	12	13	1
L	61	18	11	10	Tr
9 U	58	16	12	13	Tr
L	56	19	10	15	Tr
10 U	50	14	12	25	Tr
L	58	15	16	11	Tr
12 U	59	12	13	9	Tr
L	80	7	11	3	Tr

* Depths listed in column 3 of table B'5; U = upper section; L = lower section of each core

** Trace = <1%

Table B'7

Mineral Percentages of the Sand Fraction (>62 μm) for 10 Cores Collected from the James River Channel near Windmill Point (See Figure 5) and the Dredge Inlet Pipe to the Diked Containment Area During Active Dredging

Core Number*	Quartz (%)	K-feldspar (%)	Plagioclase Feldspar	Muscovite Mica	Amphibole
2 U	55	16	18	11	0
L	54	16	15	15	0
3 U	56	23	14	7	0
L	66	12	18	4	0
4 U	48	24	16	13	0
L	53	23	19	5	0
5 U	61	16	17	6	0
L	65	14	15	7	0
6 U	67	19	14	Tr**	0
L	46	22	21	11	0
7 U	67	21	12	0	0
L	52	14	16	0	0
8 U	64	26	10	0	0
L	64	24	12	0	0
9 U	68	20	Tr	12	0
L	62	18	20	1	0
10 U	64	10	18	4	0
L	66	10	19	5	0
12 U	84	5	8	3	0
L	80	7	11	3	0
Dredge pipe sediment sample taken 1130 hr 31 January 1975 during active dredging					
	69	11	18	3	0

* Depths listed in column 3 of table B'5; U = upper section, L = lower section of each core

** Trace = <1%

Table B'8

Measurements for Cation Exchange Capacity and Mineralogy of the less than 2 μm Fraction for 10 Cores from the James River near Windmill Point. (See Figure 5)

Core Number	Core Section and Depth Interval (cm)*	Cleaned Samples** CaEC	Cleaned Samples** K/EC	Untreated† CaEC	Untreated† K/EC	Quartz (%)	Plag. Feldspars (%)	Potassium Feldspars (%)	Muscovite (%)	Illite (%)	Kaolinite (%)	Smectite (%)	Vermiculite (%)	Mixed-layered (%)	Chlorite (%)
2	U (13-25)	30.81	17.34	27.13	22.73	41	10	9	7	16	1	2	2	5	8
	L (78-89)	31.81	22.02	25.69	23.97	36	8	10	6	18	2	3	5	5	5
3	U (13.25)	32.07	23.13	34.16	18.01	45	7	8	5	13	1	3	5	8	5
	L (80.90)	34.79	16.90	24.96	29.60	47	13	11	5	10	1	4	1	2	6
4	U (00-13)	32.51	15.99	23.70	24.28	29	8	12	8	19	2	3	6	5	2
	L (78-88)	30.23	19.86	36.08	15.06	38	10	13	6	15	1	2	1	3	11
5	U (01-12)	28.09	22.59	72.87	36.28	37	7	8	8	15	2	3	2	8	10
	L (75-84)	30.22	19.77	30.82	8.08	37	7	7	5	19	2	3	4	3	12
6	U (02-13)	33.84	22.90	29.41	11.87	31	8	13	9	17	1	2	5	3	11
	L (59-68)	27.51	17.51	26.58	10.68	39	11	11	5	12	2	2	6	6	7
7	U (11-30)	28.23	---	26.16	14.99	28	11	11	6	15	2	3	7	4	12
	L (76-95)	25.98	14.43	25.36	11.13	37	9	11	4	17	4	2	1	4	8
8	U (01-11)	35.36	19.77	26.40	14.31	32	7	11	7	16	4	3	7	4	7
	L (77-86)	31.08	16.55	31.60	13.35	32	6	10	5	19	3	3	8	6	6
9	U (00-11)	25.43	23.17	38.50	17.89	30	6	8	7	20	1	4	4	5	14
	L (77-86)	36.29	12.61	34.50	18.72	35	7	11	8	13	2	6	8	5	5
10	U (02-11)	35.18	29.11	32.07	13.72	29	7	8	14	17	1	3	4	4	14
	L (70-80)	34.39	18.03	41.56	14.49	47	13	9	6	11	1	2	2	3	6
12	U (11-30)	28.72	17.24	30.35	11.63	20	3	2	6	31	2	4	5	5	26
	L (58-83)	33.22	21.18	34.22	14.19	20	3	2	1	30	Tr††	7	5	11	22

* Depths are from top of sediment within cores; U = upper section, L = lower section of each core

** Samples were chemically treated to remove colloidal carbonate coatings, organic material, and colloidal iron coatings

† Samples were washed in distilled water to remove salts and to separate the less than 2 micron fractions which were used in these analyses

†† Tr = <1%

Table B'9

Concentrations of Suspended Solids (mg/l) at the Effluent Pipe of the Intertidal Diked Containment Area on the James River near Windmill Point During Active Dredging. Sampling Period Was from January 26 to February 3, 1975. Dredging Was Terminated at 0700 hrs on February 4

Date	Location or Time	Suspended Solids Concentration (mg/l)	Date	Location or Time	Suspended Solids Concentration* (mg/l)
Jan 1975			Feb 1975		
26	Inside dike*	545	1	1200**	11,510
26	Inside dike	530	1	1400**	10,360
26	Inside dike	495	1	1600**	5,790
26	Inside dike	500	1	1800**	1,160
26	Inside dike	510	1	2000**	730
26	Inside dike	474	1	2200**	41,130
26	Inside dike	510	1	2400	47,350
26	Inside dike	535			
26	Channel*	58	2	0200	48,230
26	Channel	67	2	0400	26,830
26	Channel	36	2	0600	41,870
26	Channel	51	2	0800**	8,950
			2	1000	72,310
30	1330†	171,568	2	1200	128,200
30	1530	146,592	2	1400	140,240
30	1730	132,830	2	1600	60,930
30	2130	326,485	2	1800	76,590
30	2330	333,870	2	2000	96,560
			2	2200	101,070
31	0530	114,300	2	2400	72,210
31	1130	319,360			
31	1215††	153,289	3	0200	26,460
31	1245††	164,400	3	0400	29,920
			3	0600	42,020
			3	1200††	152,970
			3	1238††	172,440

* These data provide an indication of replication for sampling, by hand, inside the dike near the outfall pipe and in the narrow channel between the diked containment area and the southern band of the James River

** Entire sample volume was used; probably not a representative sample

† Unless otherwise specified, the remainder of the suspended solids samples were collected with an ISCO automatic water sampler and are not representative (as illustrated in comparison studies on May 13-15, 1975)

†† Hand collected at the 18.3-m effluent pipe near the surface

Table B'10

Concentrations of Suspended Solids (mg/l) at the Effluent Pipe of the Intertidal Diked Containment Area on the James River near Windmill Point Immediately Following Dredging. Sample Collection Was from February 4 to 11, 1975, During the Settling and Dewatering Period

Date	Time	Suspended Solids Concentration* (mg/l)	Date	Time	Suspended Solids Concentration* (mg/l)
Feb 1975			Feb 1975		
4	1030	3,200	10		900
4	1230	25,400	10	1045**	600
4	2030	14,200	10	1015**	800
4	2230	62,500	10	1030	3,360
			10	1200	840
5	0030	7,300	10	1330	550
5	0830	2,300	10	1500	510
5	1030	900	10	1630	980
5	1230	800	10	1800	730
5	1230**	600	10	1930	440
5	1245**	500	10	2100	350
			10	2230	350
6	1130†	4,800	10	2400	510
6	1330†	2,690			
6	2130	260	11	0130	550
6	2330	820	11	0300	590
			11	0430	730
7	0130	660	11	0600	310
7	0930	2,330	11	0730	300
7	1130	390	11	0900	280
			11	1030	310
8	1000	700	11	1100**	310
8	1200	500			
8	1400	700			
8	2400	1,000			
9	1200	800			
9	2400	700			

* Unless otherwise specified, the suspended solids samples were collected with an ISCO automatic water sampler and are not representative (as illustrated in the comparison studies on May 13-15, 1975)

** Hand collected at the 18.3-m effluent pipe near the surface

† Recorded in data log as not representative because the entire sample had to be used for measurement of suspended solids

Table B'11

Concentrations of Suspended Solids* (mg/l) at the 18.3-m Effluent Pipe of the Intertidal Diked Containment Area on the James River near Windmill Point During a 48-hr Sampling Period for May 13-15, 1975

Date	Time	Observations	Tidal Tables**	ISCO†	Hand Collection††	Date	Time	Observations	Tidal Tables**	ISCO†	Hand Collection††
May 1975						May 1975					
13	1220	Low - Max Ebb	L = 1113	546	708	14	1200	Low	L = 1155	4,670	39,350
13	1300	Low		550		14	1300	Low		1,153	
13	1430	Low		276		14	1400	Low		555	
13	1600	Low		224		14	1500	Low		247	
13	1700		H = 1645	179		14	1600	Low		258	
13	1800	High		176	121	14	1700		H = 1731	195	
13	1900	High		326		14	1800	High		126	86
13	2000	High		1,884		14	1900	High		106	
13	2100	High		1,433		14	2000	High		196	
13	2200	High		1,464		14	2100			1,965	
13	2300		L = 2308	798		14	2200	Low		2,796	
13	2400	Low		1,190	1,575	14	2300	Low		2,056	
						14	2400	Low	L = 2350	2,251	1,777
14	0100	Low		472							
14	0200	Low		183		15	0100	Low		1,135	
14	0300	Low		241		15	0200	Low		432	
14	0400	Low		136		15	0300			250	
14	0500		H = 0507	127		15	0400			261	
14	0600	High		117	102	15	0500			164	
14	0600	High		124		15	0600	High	H = 0553	112	111
14	0800	High		100		15	0700	High		81	
14	0900	High		1,552		15	0800	High		80	
14	1000	High		947		15	0900	High		2,244	
14	1100			2,516		15	1000	High		5,294	

* Unless otherwise specified, the suspended solids samples were collected with an ISCO automatic water sampler and are not representative, as illustrated in columns 6 and 12

** Times of high and low tides from NOAA tables

† Data from ISCO automatic water sampler

†† Data from hand collection near the ISCO inlet port when the sampler was pumping

Table B'12

Measurements of Temperature, Suspended Solids, pH, Alkalinity, Eh, and Dissolved Oxygen at the Effluent Pipe of the Intertidal Diked Containment Area on the James River near Windmill Point During a Tidal Period in May 1975 (3.5 Months After Dredging). Data Are Listed with Respect to the Nearest Tidal Period, Which Is Provided in Column 9

Collection Time	Observed Tidal Stage	Temp (°C)	Suspended Solids* (mg/l)	pH	Alkalinity** (meq/l)	Eh† (mV)	Dissolved Oxygen (mg/l)	Predicted Tidal Time††	Predicted Height (ft)††
1215	low	29.2	708	6.63	--	+526	1.91	1113	-0.1
1800	high	24.6	121	8.20	0.2	+408	10.15	1645	+2.1
2400	low	15.4	1,575	5.90	1.4	+442	1.5	2308	-0.1
0600	high	17.1	102	7.13	0.5	+440	10.70	0507	+2.7
1200	low	30.3	39,350	6.35	0.5	+424	3.30	1155	-0.1
1800	high	25.2	86	7.89	0.4	+425	13.89	1731	+2.1
2400	low	17.8	1,777	6.41	0.8	+432	3.28	2350	-0.1
0600	high	18.4	111	6.67	--	+456	8.29	0553	+2.6

* Collected by hand

** The alkalinity data were too inaccurate for any interpretative purposes

† Corrected for the saturated calomel electrode

†† Predicted, time and height of tides at Windmill Point from NOAA tables

Table B'13

Dissolved Nutrients and Total Phosphorus and Nitrogen (mg/l) at the Effluent Pipe of the James River Artificial Habitat Development Site for January 31 Through February 1 (Active Dredging), February 6 Through 8 (Dewatering), and 3.5 Months Later for the Period May 13-15, 1975. N = Dissolved Nutrients (Columns 8-11), B = Total Phosphorus (Column 6) and Total Kjeldahl Nitrogen (Column 7) for Unfiltered Water Samples. For January 31 Through February 1 and February 6 Through 8, 1975, Periods

	Time	Date	Tide	Code	TP	TKN	NO_3	NO_2	PO_4	NH_4
I*	1200	131	L	N			0.043	0.024	0.040	
I	1715	131	H	N			0.039	0.013	0.048	15.43
I	1900	131	H	N						26.46
I	2230	131	L	N			0.042	0.018	0.037	18.43
I	0345	201	H	N			0.022	0.010	0.033	
I	0530	201	H	N						15.21
I	0900	201	H	N						14.88
I	1130	201	L	N			0.013	0.007	0.020	
I	1145	201	L	N			0.017	0.009	0.023	
I	1200	131	L	B	0.096	25.5				
I	1715	131	H	B	0.075	20.4				

* I = ISCO collected samples

(continued)

Table B'13 (Continued)

For the January 31 Through February 1 and February 6 Through 8, 1975, Periods

	Time	Date	Tide	Code	TP	TKN	NO_3	NO_3	PO_4	NH_4
I*	1900	131	H	B						
I	2230	131	L	B	0.109	23.2				
I	0345	201	H	B	0.070	16.5				
I	0530	201	H	B						
I	0900	201	H	B						
I	1130	201	L	B	0.075	24.4				
I	1145	201	L	B	0.200	23.0				
I	1130	206	H	N			0.192	0.013	0.024	
I	1330	206	H	N			0.120	0.013	0.028	
I	2130	206	H	N			0.351	0.024	0.040	
I	2330	206	H	N			0.344	0.017	0.017	

* I = ISCO collected samples

(continued)

Table B'13 (Continued)

For the January 31 Through February 1 and February 6 Through 8, 1975, Periods

	Time	Date	Tide	Code	TP	TKN	NO_3	NO_2	PO_4	NH_4
I*	0130	207	H	N			0.203	0.009	0.028	
I	0930	207	H	N			0.360	0.024	0.024	
I	1130	207	H	N			0.488	0.040	0.023	
I	1530	207	L	N			0.475	0.035	0.030	0.579
I	1930	207	L	N			0.378	0.029	0.021	0.052
I	0330	208	H	N			0.303	0.027	0.032	
I	0530	208	L	N			0.355	0.028	0.025	0.118
I	0730	208	L	N			0.217	0.016	0.028	
I	1130	208	H	N			0.515	0.050	0.024	
I	1130	206	H	B	0.045	11.6				
I	1330	206	H	B	0.040	13.7				

* I = ISCO collected samples

(continued)

Table B'13 (Continued)

For the January 31 Through February 1 and February 6 through 8, 1975, Periods

	Time	Date	Tide	Code	TP	TKN	NO_3	NO_2	PO_4	NH_4
I*	2130	206	H	B	0.040	5.10				
I	2330	206	H	B	0.051	16.7				
I	0130	207	H	B	0.040	10.9				
I	0930	207	H	B	0.100	10.7				
I	1130	207	H	B	0.055	4.20				
I	1530	207	L	B	0.035	4.60				
I	1930	207	L	B	0.030	10.9				
I	0330	208	H	B	0.040	14.4				
I	0530	208	L	B	0.025	12.3				
I	0730	208	L	B	0.035	30.2				
I	1130	208	H	B	0.035	6.70				

* I = ISCO collected samples

(continued)

Table B'13 (Concluded)

For May 13-15, 1975, Period at the Effluent Pipe. Additional Parameters for This Time Period: TDN = Total Dissolved Nitrogen (Column 12), and TDP = Total Dissolved Phosphorus (Column 13) for Filtered Water Samples

	Time	Date	Tide	Code	TP	TKN	NO_3	NO_2	PO_4	NH_4	TDN	TDP
H*	1215	513	L	N			0,532	0,027	0,030	2,492	2,708	0,130
H	1800	513	H	N			0,207	0,022	0,040	0,291	0,832	0,093
H	2400	513	L	N			0,131	0,024	0,030	1,782	4,272	0,046
H	0600	514	H	N			0,249	0,019	0,030	0,296	0,587	0,028
H	1200	514	L	N			0,196	0,024	0,078	2,277	4,784	0,083
H	1800	514	H	N			0,224	0,021	0,029	0,201	1,168	0,125
H	2400	514	L	N			0,091	0,018	0,038	1,350	3,672	0,147
H	0600	515	H	N			0,242	0,020	0,030	0,235	1,125	0,142
H	1215	513	L	B	0,912	4,18						
H	1800	513	H	B	0,090	0,93						
H	2400	513	L	B	0,538	5,32						
H	0600	514	H	B	0,141	1,34						
H	1200	514	L	D	1,334	6,55						
H	1800	514	H	B	0,216	1,83						
H	2400	514	L	B	0,811	4,87						
H	0600	515	H	B	0,193	1,01						

* H = hand collected samples near the inlet port to the ISCO automatic sampler

Table B'14

Dissolved Metals (mg/l) and Particulate Metals (μg/g; Dry Weight) at the Effluent Pipe of the James River Artificial Habitat Development Site for January 31 Through February 1 (Active Dredging), February 6 Through 8 (Dewatering), and 3.5 Months Later for the Period May 13-15, 1975. I = Collected with ISCO Sampler, H = Hand Sample; H = High Tide, L = Low Tide; M = Dissolved Metals, A = Particulate Metals. Missing Data Are Generally Designated as Below Detection for Specific Parameter. Date Is Listed as Month and Day

	Time	Date	Tide	Code	Ca	Cd	Cu	Fe	Hg	Mn	Ni	Pb	Zn
I	1530	131	H	M	53.10		0.050	0.784	.0034	0.213	0.020	0.323	3.077
I	2045	131	L	M	38.30	0.005	0.008	0.250	.0020	0.428			1.144
I	0015	201	L	M	56.37	0.029	0.078	1.867	.0032	0.900	0.030	0.133	9.093
I	0715	201	H	M	44.05	0.005	0.020	0.279		0.190			1.912
I	1130	201	L	M	59.65	0.005	0.016	6.913	.0019	1.496	0.017		1.490
I	1145	201	L	M	95.86	0.037	0.100	15.01	.0012	1.924	0.059	0.150	9.487
I	1530	131	H	A			56.05	33890		1282	34.57	78.04	
I	2045	131	L	A		2.44	70.00	59540		1392	49.30	88.48	198.6
I	2345	131	L	A		2.38	85.86	31720		1250	37.27	77.92	236.0
I	0015	201	L	A		2.92	62.27	52130		1327	54.07	79.19	203.8

(continued)

Table B'14 (Continued)

For the Period January 31 Through February 1 and February 6 Through 8

	Time	Date	Tide	Code	Ca	Cd	Cu	Fe	Hg	Mn	Ni	Pb	Zn
I	0800	201	H	A		1.98	47.54	36070		1129	32.75	65.27	213.6
H	1100	201	D*	A		2.59	71.86	43520		1603	50.71	97.03	266.7
I	1130	206	H	M**	35.68	0.012	0.045	5.803	.0011	1.161			0.023
I	2130	206	H	M	21.35	0.026	0.006	0.180	.0012	0.054			0.069
I	0130	207	H	M	42.89	0.012	0.008	0.025	.0009	0.202			0.046
I	0930	207	H	M	22.59	0.015		0.102	.0009	0.111			0.023
I	1530	207	L	M	16.45	0.011	0.006	0.166	.0006	0.066	0.034		0.176
I	1930	207	L	M	32.48	0.029	0.006	0.138		0.156	0.016		0.097
I	0330	208	H	M	34.08	0.007		0.043	.0007	0.156			0.032
I	0730	208	L	M	64.26	0.014		0.054	.0007	0.372	0.031		0.037
I	1130	208	H	M	8.619	0.006		0.180	.0006	0.032			

(continued)

* D = dredge inlet pipe to the development site during active dredging

** Suspended solids insufficient for particulate metal analyses during the dewatering period

Table B'14 (Concluded)

For the May 13-15 Period at the Effluent Pipe

	Time	Date	Tide	Code	Ca	Cd	Cu	Fe	Hg	Mn	Ni	Pb	Zn
H	1215	513	L	M	14.69			0.351	.0010	0.493			0.044
H	1800	513	H	M	13.08			0.142	.0002	0.021			0.012
H	2400	513	L	M	21.38			0.517		0.504	0.022		0.015
H	0600	514	H	M	14.11			0.114		0.018			0.008
H	1200	514	L	M	8.447			0.837	.0024	0.269	0.026		0.030
H	1800	514	H	M	13.66			0.329	.0002	0.024			0.008
H	2400	514	L	M	20.41	0.003	0.006	0.365	.0003	0.269			0.048
H	0600	515	H	M	13.94			0.316	.0002	0.042			0.014
H	1215	513	L	A			59.97	66280		1602	31.5	105.6	590.3
H	1800	513	H	A			23.96	65230		1710		146.2	364.1
H	2400	513	L	A			53.98	57690		1170	41.3	84.69	300.6
H	0600	514	H	A									
H	1200	514	L	A			78.98	75120	1.50	1005	65.5	114.1	636.0
H	1800	514	H	A				63050		5265			3403
H	2400	514	L	A				71990		1637	79.4	124.3	454.9
H	0600	515	H	A			296.3	71240		2783		337.3	1838

Table B'15

Measurements of Size Analyses of the Suspended Material at the Effluent Pipe of the Intertidal Diked Containment Area on the James River near Windmill Point. Data Are Listed with Respect to the Nearest Tidal Period for Active Dredging and 3.5 Months Later

Time	Date	Tidal Phase	Mean (ϕ)	Sorting Coefficient (ϕ)	Skewness	Kurtosis	Sand (%)	Silt (%)	Clay (%)	Modes (ϕ) 1	2	3	Conc. (g/l)
PERIOD -- ACTIVE DREDGING													
1150	Jan 28	dredge pipe*	7.0	3.3	0.23	-0.48	22.04	39.83	38.15	3.71	5.48	9.39	--
1330	Jan 30	high	8.1	2.9	0.200	-0.48	2.95	55.36	41.70	5.80	--	--	172.0
1400	Jan 30	dredge pipe*	7.3	3.0	0.24	-0.39	9.33	52.01	38.66	4.58	6.38	9.48	--
1130	Jan 31	low	8.7	3.0	0.02	-0.57	3.87	44.36	51.77	7.00	--	--	320.0
1130	Feb 1	low	8.3	2.9	0.14	-0.56	2.64	47.89	49.47	5.75	9.43	--	--
1145	Feb 1	dredge pipe*	7.3	3.0	0.23	-0.38	10.86	51.43	37.71	4.56	7.30	--	11.5
0000	Feb 2	low	7.4	2.3	0.45	-0.27	1.12	67.36	31.52	4.65	7.30	--	47.4
1400	Feb 3	dredge pipe*	7.2	2.9	0.27	-0.30	10.83	55.12	34.05	4.60	7.31	9.36	172.0
PERIOD -- 3.5 MONTHS AFTER DREDGING													
1230	May 13	low	8.6	2.4	-0.133	-0.13	0.16	22.94	76.90	5.03	9.03	--	0.708
0015	May 14	low	9.5	2.6	0.06	-0.63	0.15	46.79	53.06	7.69	--	--	1.575
0015	May 14	low**	9.4	2.5	0.08	-0.51	0.21	35.87	63.92	7.59	--	--	
1000	May 14	low	6.4	1.9	0.04	-0.48	3.81	68.21	27.98	5.12	--		0.447
1209	May 14	low	9.6	2.4	-0.04	-0.35	0.34	23.15	76.52	6.33	9.39	--	4.7
1210	May 14	low**	8.6	2.9	0.10	-0.61	0	49.73	50.27	5.01	7.15	9.91	39.4
1545	May 14	high	8.5	2.7	0.21	-0.50	0.60	58.56	40.83	7.21	--	--	--

* At the dredge pipe. All other samples were collected at the effluent pipe

** These two samples were collected approximately 25 cm below the water surface at the effluent pipe, while all other samples in this table were collected at the surface

Table B'16

Mineral Percentages of the Clay Fraction (<2 μm) from Suspended Sediment at the Effluent Pipe of the Intertidal Diked Containment Area on the James River near Windmill Point During Active Dredging and 3.5 Months Later

Time	Date	Tidal Phase	Illite (%)	Chlorite (%)	Mixed-Layered Illite-Chlorite (%)	Vermiculite (%)	Smectite (%)	Kaolinite (%)
Active Dredging Period								
1130	Jan 31	low	45	29	12	6	4	4
1130	Feb 2	low	49	31	14	2	4	Tr**
3.5 Months After Dredging								
0015	May 14	low	49	20	18	2	4	7
0015	May 14	low*	50	21	18	Tr	5	7
1000	May 14	low	46	25	11	9	5	4
1210	May 14	low*	43	20	22	8	8	Tr
		Mean	45	26	16	6	4	3
		Std. Dev.	7	5	4	6	3	3

* Sample was collected 25 cm below water surface at the effluent pipe. All other samples were collected at the surface

** Trace = <1%

Table B'17

Mineral Percentages of the Silt Fraction (2-62 μm) from Suspended Sediment at the Effluent Pipe of the Intertidal Diked Containment Area on the James River near Windmill Point During Active Dredging and 3.5 Months Later

Time	Date	Phase	Quartz (%)	K-feldspar (%)	Plagioclase Feldspar (%)	Muscovite Mica (%)	Amphibole (%)
Active Dredging Period							
1130	Jan 31	low	65	13	13	10	Tr*
1130	Feb 2	low	51	16	13	21	Tr
3.5 Months After Dredging							
0015	May 14	low	61	16	10	13	Tr
1000	May 14	low	51	16	15	18	Tr
1210	May 14	low	44	18	13	22	2
Statistics for Entire Period							
		Mean	56	16	15	15	--
		Std. Dev.	8	2	4	8	--

* Trace = <1%

Table B'18

Measurements for Cation Exchange Capacity and Mineralogy of the Suspended Sediments at the Effluent Pipe of the Intertidal Diked Containment Area on the James River near Windmill Point During Active Dredging and 3.5 Months Later

Time	Date	Tidal Phase	CaEC* Cleaned	CaEC* UNT	K/EC* Cleaned	K/EC* UNT	Qtz (%)	Plag (%)	K-feld (%)	Mus (%)	Illite (%)	Kaol (%)	Smect (%)	Verm (%)	ML (%)	Chl (%)
PERIOD -- ACTIVE DREDGING (Jan 31 - Feb 2, 1975)																
1130	Jan 31	low	26.45	--	12.21	--	31	6	6	5	23	2	2	3	6	15
1130	Feb 2	low	88.39	--	12.53	--	--	--	--	--	--	--	--	--	--	--
PERIOD -- 3.5 MONTHS AFTER DREDGING (May 13-15, 1975)																
0015	May 14	low	35.66	24.30	20.58	10.41	--	--	--	--	26	4	2	1	10	11
0015	May 14	low**	24.20	43.80	27.81	15.23	22	4	6	5	32	4	3	Tr†	12	13
1000	May 14	low	--	--	--	--	37	11	12	13	13	1	1	3	3	7
1209	May 14	low	19.67	27.81	7.35	10.34	--	--	--	--	--	--	--	--	--	--
1210	May 14	low**	28.63	27.95	24.45	10.96	22	7	9	11	22	Tr	4	4	11	10

* See text for procedures associated with cleaned and untreated calcium and potassium exchange capacity measurements

** Samples were collected about 25 cm below water surface at the effluent pipe. All other samples were collected at the surface

† Trace = <1%

Table B'19

Descriptions of Sediment Cores from the James River Artificial Habitat Development Site in July 1975 for the High Marsh, Intertidal, and Subtidal Coring Locations

Core Number: FJR-5 Location: (100,400) High Marsh

Total Length: 57 cm

Sampled for size analysis and Atterberg limits at 7 cm, 38 cm, 49 cm, and 55 cm.

Depth Interval (cm)	Description
0-5	Indistinct layers (about 5 mm thick); very dark gray-brown (10YR-3/2)*; sandy mud; well compacted and cohesive.
5-21	Distinct layers (3 to 5 mm thick); compact, dark gray-brown (2.5Y-3/2), silty clay with discontinuous layers (1 cm thick) of dark gray (5Y-3/1); some gravel-sand layers; small amount of < 1-mm black plant fragments.
21-41	Occasional sandy layers within apparently homogeneous, very dark gray (2.5Y-3/2) compact silty clay with patches of darker gray (5Y-3/1) faint mottling.
41-44	Gravel (3 to 5 mm) with dark olive gray (5Y-3/2) clay matrix (< 10% matrix), moderately sorted gravel.
44-54	Distinct 0.2- to 2-cm layers of very dark grayish-brown (2.5Y-3/2) silty clay with several large (5 mm) pebbles throughout; muscovite mica flakes and 1- to 5-mm black plant fragments are abundant; sharp contacts between layers.
54-57	Layer of very dark grayish brown (2.5Y-3/2) mud matrix with gravel-size quartz pebbles (2 to 6 mm) coated with brown hematite.

* Munsell color chart

(continued)

Table B'19 (Continued)

Core Number: FJR-4 Location: (250,300) Intertidal Marsh

Total Length: 104 cm

Sampled for size analysis and Atterberg Limits at 4 cm, 12 cm, 51 cm, 64 cm, 71 cm, 80 cm, 91 cm, and 103 cm.

Depth Interval (cm)	Description
0-70	Indistinct layers (2 to 3 mm thick) to apparent homogeneous, very dark grayish-brown (2.5Y-3/2)* silty-clay; top 5 cm somewhat more compact perhaps due to dessication; black plant fragments (1 to 5 mm long) apparently oriented with long dimension parallel to horizontal and concentrated in layers (about 1 cm thick) especially between 40 and 70 cm depth; irregularly shaped gas vesicles (2 to 10 mm) throughout; distinct silty layers with abundant plant debris between 68 and 70 cm depth; sharp contact with sediment below 70 cm depth.
70-79	Indistinct laminae (< 1 mm) of dark grayish-brown (2.5Y-4/2) silty clay; only a few black plant fragments (2 to 5 mm long); sharp but irregular contact with sediment below 79 cm depth.
79-104	Indistinct laminae (1 to 5 mm) of dark olive gray (5Y-3/2), very silty clay; black plant debris (0.5 to 3 mm long) concentrated in occasional layers spaced several centimeters apart with several of these layers between 79 and 82 cm depth, only a few small gas vesicles (< 5 mm diameter) scattered throughout.

* Munsell color chart

(continued)

Table B'19 (Concluded)

Core Number: FJR-10 Location: (1100,150) Subtidal Marsh

Total Length: 106.5 cm

Samples taken for size analysis and Atterberg Limits at 6 cm, 49 cm, 57 cm, and 102 cm.

Depth Interval (cm)	Description
0-45	Homogeneous, loosely compacted, very dark grayish-brown (2.5Y-3/2)* silty clay; uniform distribution of abundant (about 5% by volume) black plant debris (0.5 to 7 mm in size); abundant (5 to 10% by volume) circular to irregularly shaped gas vesicles (1 to 10 mm in size) throughout, some of these vesicles are interconnected, especially in uppermost 15 cm.
45-53	Indistinct laminae (about 1 mm thick) of very dark grayish-brown (2.5Y-3/2) fine clay; less than 5% (by volume) of 1- to 2-mm black plant fragments; only a few small (< 5 mm) gas vesicles.
53-60.5	Distinct 1- to 3-mm laminae of dark olive gray (5Y-3/2) sandy silt with abundant muscovite mica; sand grains are as large as 1 mm; a 5-mm laminae of dark grayish-brown (2.5Y-4/2) silty clay occurs at 53 cm depth; no gas vesicles.
60.5-83	Distinct 1- to 2-mm laminae of very dark grayish-brown (2.5Y-3/2) clay with abundant black plant debris oriented in laminae especially between depths of 77 and 81 cm; 2- to 7-mm irregular to circular shaped gas vesicles are common (< 3% by volume).
83-106.5	Indistinct laminae (1 to 5 mm thick) of dark grayish-brown (2.5Y-4/2) clay; small amount of black plant debris (< 2 mm in size); small (< 3 mm) irregularly shaped gas vesicles are rare (< 1% by volume).

* Munsell color chart

Table B'20

Sediment Description of a 76-cm Core Collected at the Reference Marsh from the Subtidal Location on August 6, 1976

0-52 cm	Dark grayish brown (2.5Y-4/2)*, homogeneous, very fine-grained mud with no apparent layering; abundant fibrous vegetation; loosely packed 0-15 cm becoming more consolidated with depth; obvious horizontal orientation of plant debris (wood fragments and fibers) from 30-52 cm depth; large plant debris (0.5 cm in length by 0.3 cm wide); some plant fibers 15-20 cm long and as wide as 0.5 mm, possibly rootlets; faint contact at 39 cm depth; very sharp contact at 52 cm depth; contact irregular with up to 2 mm relief in the vertical.
52-63 cm	Very dark grayish brown (2.5Y-3/2) to dark grayish brown (2.5Y-4/2) mottled, very fine-grained mud; abundant plant debris with some faint layering due to mostly horizontally oriented plant debris, mostly leaf or stalk fragments (up to 12 × 2 mm) with some fibrous vegetation; more compacted than sediment from 0-52 cm depth interval above.
63-79 cm	Very dark gray (10YR-3/1), very fine-grained mud with abundant plant fragments (both stalk and fibrous debris) in 1-2 cm thick layers; plant debris oriented horizontally, some oval segments as large as 8 mm in diameter, most compact sections of sediments in the core; plant debris from a cohesive mat binding the sediment, especially in a layer from 71-73 depth.

* Munsell color chart

Table B'21

Field Observations (Temperature, pH, and Eh) and Percent Water for Cores Collected from the James River Artificial Habitat Development Site During July 1975

Site	Location Coordinates	Core Number	Depth Below Surface* (cm)	Water** (%)	Temp† °C	pH	Eh†† (mV)	Total Length‡ (cm)
High Marsh (H)	100,400	17	U 005	13.9	17.0	7.40	007	51
			M 045	33.4	19.0	7.32	329	
		26	U 000	17.0	22.0	7.46	304	50
			M 035	15.8	17.0	7.11	-001	
Intertidal (I)	250,300	15	U 009	47.1	23.0	6.40	027	124
			L 109	41.9	21.0	6.61	011	
		25	---	---	18.0	6.36	039	140
			L 125	46.3	19.0	6.54	002	
Subtidal (S)	1100,150	3	U 004	53.1	25.0	6.58	055	109
			M 054	37.5	26.0	6.75	028	
			L 104	45.4	22.0	6.58	060	
		9	U 013	56.2	26.0	6.44	038	108
			L 093	56.4	28.0	6.63	034	

* Depth of the probe analyses for each core

** Water content by oven drying at 60°C. Samples collected in the field with special 50 cc syringes for total sulfide analysis

† Not field temperature, but obtained during probe analysis within a few hours after collection

†† Average of redox measurements with two platinum electrodes, with correction for the potential of the calomel electrode (+254 mV)

‡ Total length from measurement in the field before probe analysis

Table B'22

Interstitial and Total Nutrients and Carbon for Cores Collected from the James River Artificial Habitat Development Site in July 1975

Site	Location Coordinates (x,y)	Core Number	Core Section* (cm)	TP (μg/g)	TKN (μg/g)	TOC** (μg/g) Glass Vials	TOC** (μg/g) Plastic Bags	DOC (mg/l)	TDP (mg/l)	TDN (mg/l)	$NO_3 + NO_2$ (mg/l)	PO_4 (mg/l)	NH_4 (mg/l)	Depth Interval for NH_4 (cm)
High Marsh (H)	100,400	17	U (0-22)	790.1	2331	---	19,105	---	0.191	36.23	0.035	0.060	33.6	(15-30)
			M (22-46)	827.6	2781	17,506	18,386	---						
		26	U (0-22)	812.7	4296	---	17,258	---	---	---	---	---	42.3	(0-20)
			M (22-46)	801.4	2317	19,323	15,119	33.4	0.172	30.65	0.004	0.048	---	
Intertidal (I)	250,300	15	U (0-26)	719.5	2790	19,057	---	67.5	0.219	13.09	0.025	0.054	18.5, 19.2†	(0-15)
			M (26-104)	861.0	3167	---	16,478	---	0.220	36.66	0.025	0.053	34.6	---††
			L (104-130)	834.1	4184	17,636	---	55.9	0.296	27.66	0.023	0.054	44.8	---††
		25	U (0-26)	728.6	3150	18,353	19,105	40.9	---	---	---	---	25.9, 24.8†	(0-20)
			M (26-104)	812.9	4147	---	12,218	71.3	0.338	53.94	0.029	0.062	---	
			L (104-130)	973.2	4632	16,525	15,237	69.5	0.381	41.65	0.042	0.057	45.1, 45.6†	(101-116)
Subtidal (S)	1100,150	3	U (0-26)	820.6	3510	19,323	---	62.3	0.147	41.80	0.020	0.040	22.4	(0-15)
			M (26-86)	809.3	3647	18,015	---	79.1	0.153	37.23	0.024	0.042	28.3	(45-60)
			L (86-104)	861.4	2790	15,209	---	85.4	0.147	41.80	0.020	0.078	34.3	(90-105)
		9	U (0-26)	793.2	3607	15,734	---	48.7	0.137	38.08	0.027	0.043	25.7, 31.1†	(0-15)
			M (26-86)	816.7	3150	---	16,824	---	0.259	49.23	0.020	0.052	---	---
			L (86-110)	775.2	3617	14,311	---	52.6					30.3, 40.7†	(77-92)

* Depth interval for dissolved nutrients with exception of dissolved ammonium

** Sediments for total organic carbon were stored frozen either in glass vials (with aluminum foil inserts below caps) or in plastic bags

† Duplicates from different centrifuge bottles for the same depth interval

†† Depth interval not recorded in log book

Table B'23

Interstitial Dissolved Metals for Cores Collected from the James River Artificial Habitat Development Site in July 1975. All Data Are in Units of mg/l. Dissolved Mercury Was Not Measured Due to Storage Time

Site	Location Coordinates (x,y)	Core Number	Core Section (cm)	Ca	Cd*	Cr*	Cu**	Fe†	Mn†	Ni*	Pb*	Zn
High Marsh (H)	100,400	17 U + M	0 - 50	92.2				22.2 *	* 5.40			0.110
		26 U + M	0 - 50	72.7				14.6	4.75			0.483
Intertidal (I)	250,300	15 U	0 - 10	34.9				12.3	1.80			0.77
		M	25 - 40	66.7				21.9	2.20			0.12
		M	55 - 70	59.1				21.7	1.89			0.38
		M	70 - 85	57.4				20.0	2.00			0.25
		M	85 - 100	63.4				22.2	5.00			0.23
		25 U	16 - 31	106.5				57.2	3.91			0.387
		M	31 - 47	106.8 ††				54.4 ††	4.05 ††			0.926 ††
				99.5				34.4	3.22			0.295
		M	62 - 77	44.8				32.4	3.07			0.041
		M + L	97 - 112	44.2				37.2	2.87			0.087
		L	112 - 132	25.9				21.1	0.59			0.080
Subtidal (S)	1100,150	3 U	0 - 5	57.2				15.4	3.20			0.268
		M	20 - 35	89.5				37.2	2.99			0.764
		M	35 - 50	84.0				36.9	2.88			0.741
		M	65 - 80	38.8				11.2	1.66			0.252
		L	80 - 95	32.7				23.9	--**			--**
		L	95 - 110	--**					--**			--**
		9 U	0 - 5	40.7				10.0	2.20			0.04
		U	5 - 20	81.5 ††				25.9 ††	2.75 ††			0.11 ††
				76.9				25.4	2.73			0.05
		M	20 - 35	48.0				14.8	1.45			0.40
		M	35 - 50	56.6 ††				32.3 ††	3.46 ††			0.05 ††
				74.1				23.2	2.53			0.24
				91.0				30.1	3.19			0.70
		M	50 - 65	62.2 ††				20.0 ††	2.77 ††			0.05 ††
				49.3				20.2	2.73			0.05
		M	65 - 80	31.1				9.31	1.10			0.71
		L	80 - 97	15.5	---**			8.07	0.37			0.76

* Below detection limits of 0.002 mg/l for Cd, 0.015 mg/l for Cr, 0.015 mg/l for Ni, and 0.050 mg/l for Pb

** Sample volume was not sufficient to analyze for this metal

† Fe and Mn analyzed on different days gave results differing by 0-10 percent

†† Replicate samples collected in different polyethylene snap-cap vials from different centrifuge bottles for the same horizon

Table B'24

Total Sediment Metals for Cores Collected from the James River Artificial Habitat Development Site in July 1975. All Data Are in Units of μg/g

Site	Location Coordinates (x,y)	Core Number	Core Section (cm)	Ca	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Zn
High Marsh (H)	100,400	17	U 0-22*	1140	0.47	**	8.75	12,160	0.035	295	8.1	14.6	49.2
			M 22-46	3240	1.04	**	26.1	28,460	0.145	751	22.9	36.8	140
		26	U 0-22*	1740	1.08	**	14.4	16,400	0.050	402	13.2	20.0	74.8
			M 22-46	2520	0.80	**	20.4	24,040	0.085	651	17.4	30.4	113
Intertidal (I)	250,300	15	U 0-26	3420	1.77	**	13.9	42,280	0.215	1020	37.2	65.1	216
			M 26-104†	3180	1.54	**	35.1	38,000	0.195	886	32.6	52.0	176
			L 104-130†	2880	1.52	**	48.6	43,700	0.255	871	42.5	68.1	228
		25	U 0-26	4190	1.99	**	47.8	42,870	0.245	1040	39.5	71.5	226
			M 26-104	4390	1.65	71.3	46.5	43,360	**	1030	33.9	59.2	212
			L 104-130	2600	1.47	**	40.8	49,960	0.315	1160	46.0	71.8	183
Subtidal (S)	1100,150	3	U 0-26*	4180	2.43	**	59.8	48,530	0.310	1160	48.0	69.7	292
			M 26-86†	2870	1.45	**	52.9	41,810	0.265	879	40.4	64.2	224
			L 86-110	2120	1.38	**	43.7	46,800	0.315	967	43.6	72.6	170
		9	U 0-26*	4560	2.58	**	63.8	49,400	0.375	1180	48.9	95.6	298
			M 26-86	3170	2.16	**	54.4	45,360	0.225	996	43.7	72.8	244
			L 86-110	2280	1.34	**	41.4	46,240	0.180	1150	44.0	67.7	170

* Value listed is average of two digestions

** No data

† Value listed is average of three digestions

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HABITAT DEVELOPMENT FIELD INVESTIGATIONS WINDMILL POINT MARSH D--ETC(U)

AUG 78 D D ADAMS, D A DARBY, R J YOUNG DACW65-75-C-0051

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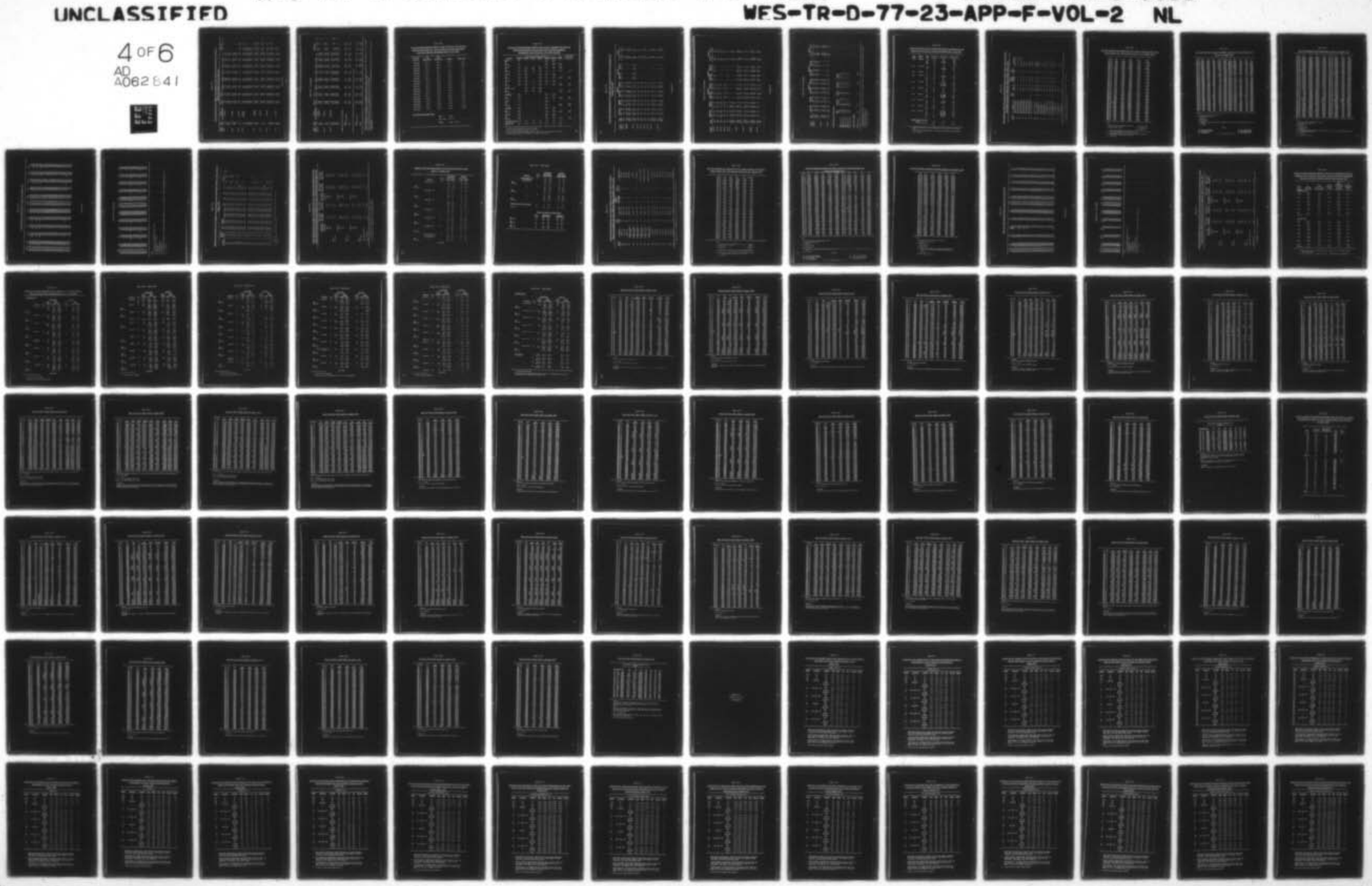

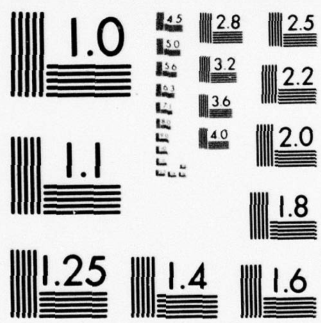

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU

Table B'25

Size Analysis Data for Samples from Sediment Cores Taken at the James River Artificial Habitat Development Site in July 1975

Sample Number	Depth (cm)	Location (x, y) Coordinates*	Mean Size (ϕ)	Sorting (ϕ)	Skewness	Kurtosis	% Sand	% Silt	% Clay	Modes (ϕ) 1	2	3	4
FJR-1	4.5	(100,150)	7.39	3.14	0.25	-0.38	9.2	56.0	34.8	4.73	--	--	--
	92		7.47	2.81	0.37	-0.29	2.0	64.4	33.6	5.14	--	--	--
	98†		4.78	2.15	1.18	2.88	43.2	49.5	7.2	3.85	--	--	--
	110.5		8.21	3.13	-0.04	-0.21	5.9	47.7	46.4	6.62	--	--	--
	163		8.80	2.73	0.14	-0.59	0.2	47.3	52.5	6.52	--	--	--
FJR-2	1.5	(250,450)	7.40	3.02	0.27	-0.37	7.1	57.4	35.5	4.74	--	--	--
	50.5		7.15	3.17	0.27	-0.40	13.7	52.5	33.9	4.58	--	--	--
	58†		4.51	2.18	1.17	2.98	49.6	43.7	6.7	3.82	--	--	--
	77†		0.61	0.96	4.84	50.45	98.6	0.8	0.6	0.50	--	--	--
FJR-3	3	(1100,350)	8.05	2.88	0.05	-0.32	6.1	43.5	50.4	6.58	4.56	8.81	--
	41.5		8.27	2.78	0.04	-0.31	2.9	44.3	52.8	5.51	7.67	9.46	--
FJR-4	4	Site AI (250,300)	7.80	2.93	0.14	-0.41	6.0	49.6	44.4	4.64	6.47	9.47	--
	14		7.98	3.15	0.14	-0.51	8.4	53.5	38.1	7.22	4.94	--	--
	51		6.62	2.97	0.46	-0.06	12.8	66.0	21.2	4.24	5.76	7.34	--
	64		6.46	2.94	0.41	-0.24	22.3	47.5	30.2	4.18	9.46	--	--
	71†		6.98	2.73	0.38	-0.13	10.1	60.5	29.4	5.46	9.48	--	--
	80†		6.08	3.16	0.44	-0.19	35.7	38.4	26.0	3.64	9.54	--	--
	91†		9.19	2.78	0.04	-0.66	0.1	42.2	57.7	5.59	4.17		
	103†		8.62	2.67	0.13	-0.46	0.3	47.8	51.9	6.67	9.52	--	--
FJR-5	7†	Site AII (100,400)	2.38	3.01	0.86	1.43	78.8	13.6	7.6	0.58	3.70	9.57	--
	38†		6.76	3.59	0.14	-0.51	28.2	35.5	36.4	3.77	9.56	6.23	--
	49†		6.98	3.39	0.20	-0.55	25.2	36.8	38.0	3.82	9.56	6.09	--
	55†		1.90	3.01	0.95	1.84	87.6	4.4	8.0	0.59	9.14	5.39	--
FJR-6	2	(1200,150)	8.17	3.12	0.13	-0.62	3.7	52.3	44.0	4.97	9.77	--	--
	6		8.04	2.87	0.13	-0.36	5.4	46.3	48.4	8.38	5.26	6.91	--
	41		7.67	3.06	0.15	-0.46	10.5	46.6	43.0	4.11	5.31	6.65	--
	44		9.08	3.01	-0.10	-0.45	3.4	39.6	57.0	7.55	--	--	--
FJR-7	2	(600,250)	8.02	3.21	0.07	-0.54	8.6	44.5	46.9	6.30	4.85	9.62	--
	8		7.44	3.48	0.08	-0.49	17.0	42.7	40.3	4.21	6.06	--	--
	58		8.92	2.89	0.04	-0.64	0.4	43.8	55.9	6.47	--	--	--
	64†		7.96	3.63	-0.06	-0.49	15.5	38.4	46.1	5.66	7.30	1.88	--
	72†		8.52	3.40	-0.09	-0.53	9.4	35.3	55.3	5.45	7.90	--	--
	124†		8.81	3.06	0.02	-0.68	0.1	45.1	54.8	4.59	6.65	--	--
FJR-8	25†	(1400,450)**	3.54	2.67	1.14	2.39	81.0	10.6	8.4	2.54	6.46	--	--
	79†		2.10	2.38	1.67	5.63	93.5	1.3	5.2	1.51	6.73	--	--
	107†		5.20	3.70	0.42	-0.26	54.5	22.2	23.3	2.45	6.06		
	119†		7.80	3.23	0.10	-0.47	8.5	49.6	41.9	6.0	--	--	--

(continued)

Table B'25 (Concluded)

Sample Number	Depth (cm)	Location (x, y) Coordinates*	Mean Size (ϕ)	Sorting (ϕ)	Skewness	Kurtosis	% Sand	% Silt	% Clay	Modes (ϕ) 1	2	3	4
FJR-10	6	Site AS (1100,150)	7.99	3.04	0.14	-0.46	5.6	50.2	44.3	6.44	4.79	8.64	--
	49		8.37	2.71	0.22	-0.48	0	54.0	46.0	6.84	--	--	--
	57†		5.39	3.94	0.37	-0.41	49.8	23.5	26.7	1.75	--	--	--
	102†		9.32	2.74	0.01	-0.65	0.1	39.9	60.1	6.64	--	--	--
FJR-11	3	(600,100)	8.45	3.21	0.02	-0.58	4.6	44.4	51.0	4.96	6.12	8.07	--
	59		8.49	3.10	0.05	-0.62	4.5	47.3	48.2	7.08	5.73	9.85	--
	67†		6.99	3.90	0.06	-0.61	29.4	32.2	38.4	2.22	7.31	--	--
	107†		9.20	2.74	0.05	-0.65	0.1	40.7	59.2	6.49	--	--	--
FJR-12	8†	(1400,325)**	3.94	3.19	0.89	1.01	76.3	9.1	14.6	2.49	--	--	--
	52†		6.04	3.35	0.42	-0.19	33.3	42.6	24.1	3.86	--	--	--
	58†		3.77	3.10	0.77	0.89	69.0	19.8	11.3	1.64	5.27	6.30	8.70
	63†		2.24	2.52	1.47	4.39	91.1	3.7	5.2	1.43	7.48	--	--
	72†		1.91	2.17	1.85	7.09	93.5	2.9	3.6	1.43	7.67	--	--
	75†		6.52	3.47	0.22	-0.35	23.1	42.0	29.0	5.16	1.75	--	--
	111†		8.01	3.48	-0.04	-0.51	13.9	38.5	47.6	6.11	2.59	--	--
Summary Statistics (All 52 Samples)													
	Mean		6.70	2.99	0.44	1.19	26.2	38.8	35.1	4.01	6.83	8.61	
	Standard Deviation		2.24	0.48	0.77	7.15	30.8	16.8	17.5	1.83	1.42	1.15	
	Range		0.61-9.32	0.96-3.94	0.1-4.84	-0.68-50.45	0-98.6	0.8-66.0	0.6-60.1	0.5-6.84	3.7-9.77	6.3-9.85	
Summary Statistics for Dredge Material Within the Dike That Does Not Contain Dike Sand (23 Samples)													
	Mean		7.92	3.02	0.15	-0.43	7.0	49.6	43.4	4.99	6.92	8.63	
	Standard Deviation		0.66	0.18	0.14	0.15	5.5	6.7	8.9	1.22	1.24	1.05	
	Range		6.46-9.08	2.71-3.48	-0.1-0.46	-0.06--0.64	0-22.3	39.6-66.0	21.2-57.0	1.24-7.55	5.76-9.77	6.65-9.85	

* These coordinates are in feet with the x axis lying nearly east-west and the y axis running north-south. The origin (0,0) is at the southwest corner of the Habitat. The boundaries of the Habitat are x=0 to 1,300 and y=0 to 500

** These cores were taken on the tidal flats adjacent to the east side of the Habitat

† These samples are not dredge material pumped into diked area, but are either predredging subbottom, dike sand or a mixture of dike sand and dredged sediment

Table B'26

Cation Exchange Capacity (NaEC) of the Less Than 62 Micron Size Fraction for Surface (0 - 10 cm) Samples from the James River Artificial Habitat Development Site in July 1976

Location (x, y)	CEC meq/100 g	CEC meq/100 g	Mean	Std. Dev.
100,400	42.5	40.5	41.5	1.36
100,300	43.0	39.5	41.2	2.49
200,100	56.9	49.8	53.4	5.07
200,300	41.2	48.7	44.9	5.33
400,100	41.0	42.7	41.8	1.20
400,250	36.1	45.5	40.8	6.67
400,400	39.4	41.5	40.4	1.48
800,100	37.3	39.7	38.5	1.65
800,200	28.0	31.6	29.8	2.60
800,225	36.5	35.9	36.2	0.41
800,300	39.9	39.0	39.4	0.63
800,400	37.3	45.2	41.2	5.55
1100,100	30.2	34.5	32.4	3.05
1100,120	38.1	35.2	36.7	2.02
1100,200	44.2	37.0	40.6	5.05
1100,300	43.6	42.1	42.4	1.07
1100,400	38.8	45.0	41.9	4.37
1200,100	39.1	40.0	39.6	0.69
1200,120	37.0	36.6	36.8	0.29

Statistics for Above Data

Mean	40.0
Std. Dev.	± 4.85
Range	29.8 - 53.4

Table B'27

Changes in Cation Exchange Capacity with Various Treatments for Selected Surface Grab Samples from the James River Artificial Habitat Development Site Collected in July 1975 and 1976

Treatment*	(1100,75)**	(1100,200)	(800,200)	(400,250)	(250,150)**	(100,300)**	Mean Std. Dev.	Avg. Δ % from <62µ Wet NaEC and Std. Dev.
	Cation Exchange Capacity in meq/100 g							
Bulk Wet	38.1	--	--	--	31.3	31.2		
NaEC	--				33.8	26.7		
Mean	38.1				32.6	28.9	33.2	--
Std. Dev.	--				± 1.7	± 3.2	± 4.2	
<62µ Wet	32.1	44.2	28.0	36.1	34.8	28.1	30.3†	
NaEC	27.4	37.0	31.6	45.5	31.4	28.3	± 2.9	
Mean	29.7	40.6	29.8	40.8	33.1	28.2	33.7	- 7.6††
Std. Dev.	± 3.3	± 5.0	± 2.6	± 6.7	± 2.4	± 0.1	± 5.7	±12.6
<62µ H_2O_2	20.4	26.8	--	32.4	17.9	18.3		
NaEC	23.2	25.9		33.4	15.9	18.9		
Mean	21.8	26.4		32.9	16.9	18.6	23.3	-36.2
Std. Dev.	± 1.9	± 0.6		± 0.7	± 1.4	± 0.5	± 6.5	±10.9
<62µ -Fe	17.5	31.3	34.4	33.4	20.0	23.6		
NaEC	20.3	40.9	--	26.4	14.8	22.5		
Mean	18.9	36.1	34.4	29.9	17.4	23.1	26.6	-23.2
Std. Dev.	± 2.0	± 6.8	--	± 4.9	± 3.7	± 0.8	± 8.0	±24.3
<62µ Wet		21.5	19.0	23.3				
H_2O_2 and -Fe NaEC		23.4	21.3	22.0				
Mean		22.5	20.2	22.7			21.8	-40.4
Std. Dev.		± 1.3	± 1.7	± 0.9			± 1.4	± 7.1
<62µ Freeze-	25.0	--	--	--	19.0	23.4		
Dried NaEC	23.0				21.1	26.0		
Mean	24.0				20.0	24.7	22.9	-30.1
Std. Dev.	± 1.4				± 1.5	± 1.8	± 2.6	±13.5
<2µ Wet	52.8	--	--	--	49.6	--		
NaEC	--				94.9			
Mean	52.8	--	--	--	72.2		65.7	+80.0
Std. Dev.	--				±32.1		±25.3	±58.6
<2µ Freeze-	22.2	--	--	--	49.9	38.4		
Dried CaEC	22.0				40.1	38.6		
Mean	22.1				45.0	38.5	35.2	+ 9.8
Std. Dev.	± 0.1				± 6.9	± 0.1	±11.0	±44.9
<0.5µ Wet	84.3	--	--	--	68.7	41.2		
NaEC	51.3				59.3	39.3		
Mean	67.8				64.0	40.2	57.3	71.1
Std. Dev.	23.4				6.7	1.4	17.2	29.2
Total Mean for Above	32.8	31.4	26.9	31.6	37.6	28.9	32.4	
Total Std. Dev.	±18.5	± 8.4	± 6.6	± 7.6	±22.3	± 7.7	±15.4	
n	14	8	5	8	16	14	65	

* See text for different methods for treatment of samples

** July 1975 sample, others were collected in July 1976

† Mean and standard deviation for samples (1100,75), (250,150) and (100,500) collected in July 1975

†† Average percent change (Δ%) in NaEC from bulk wet sample for three samples

Table B'28

Vane Shear Strength Data for the James River Artificial Habitat Development Site

During July 1975

Location* (x,y)	Depth (cm)	Undisturbed A**	Undisturbed B†	Remolded A**	Remolded B†	Replicate Undisturbed A**	Replicate Undisturbed B†	Replicate Remolded A**	Replicate Remolded B†	Replicate Undisturbed A**	Replicate Undisturbed B†	Replicate Remolded A**	Replicate Remolded B†	Average Undisturbed B†	Average Remolded r†
(100,100)	22.9	3.0	66	1.1	26	2.2	51	0.8	23	--	--	--	--	58.5	24.5
	53.3	4.8	98	1.1	26	4.1	84	1.1	26	--	--	--	--	91.0	26.0
(100,400) Site All	22.9	16.5	333	4.4	90	11.1	228	4.0	82	--	--	--	--	280.5	86
	53.3	10.2	307	2.3	54	10.9	223	2.0	47	--	--	--	--	265	50.5
	83.8	9.8	199	2.4	56	11.1	228	3.6	77	--	--	--	--	213.5	66.5
	114.3	16.7	337	3.8	77	18.8	365	3.1	68	--	--	--	--	351	72.5
	144.8	18.0	363	4.0	82	16.8	339	3.0	66	--	--	--	--	351	74
(100,400)	22.9	18.0	367	4.3	88	16.5	334	3.8	77	16.8	339	3.9	82	347	82
	53.3	12.5	253	3.5	75	11.2	230	1.8	41	10.9	223	1.5	36	235	51
	68.6	19.6	401	4.3	88	8.5	175	2.8	47	14.1	288	3.0	66	288	67
(100,300)	22.9	4.0	82	1.2	31	4.8	98	1.8	41	--	--	--	--	90	36
	48.3	10.0	203	4.3	88	6.8	139	2.3	54	--	--	--	--	171	71
(50,50)	22.9	2.1	51	0.8	20	2.9	64	1.1	28	--	--	--	--	57.5	24
	53.3	4.4	89	1.0	26	6.4	132	2.8	62	--	--	--	--	110.5	44
(50,450)	22.9	7.9	161	1.5	34	9.1	192	1.2	31	--	--	--	--	176.5	32.5
	48.3	7.5	153	2.5	58	7.0	143	1.9	43	--	--	--	--	148	50.5
(200,400)	22.9	9.6	195	0.8	23	8.8	181	1.8	41	--	--	--	--	188	32
	53.3	8.2	167	2.8	47	7.3	155	1.0	28	--	--	--	--	161	37.5
(225,300)	22.9	1.5	31	0.9	26	2.1	49	0.8	23	--	--	--	--	40	24.5
	53.3	1.0	28	0.8	23	1.5	31	0.7	20	--	--	--	--	29.5	21.5
	83.8	1.8	41	0.8	23	2.4	56	1.0	28	--	--	--	--	48.5	25.5
	114.3	3.4	76	1.1	31	4.5	92	1.2	35	--	--	--	--	84	33
	142.2	2.5	58	1.0	24	2.8	62	0.8	23	--	--	--	--	60	23.5
(225,200)	22.9	0.4	11	0.1	3	0.4	11	0.1	3	--	--	--	--	11	3
	53.3	0.7	20	0.1	3	0.9	26	0.5	14	--	--	--	--	23	8.5
	83.8	1.5	31	0.5	14	2.0	47	0.6	17	--	--	--	--	39	15.5
	114.3	3.1	68	0.8	23	3.9	80	0.9	26	--	--	--	--	74	24.5
	139.7	2.4	56	0.9	26	2.8	62	1.0	28	--	--	--	--	59	27

(continued)

Table B'28 (Continued)

Location* (x,y)	Depth (cm)	Undisturbed A**	Undisturbed B†	Remolded A**	Remolded B†	Replicate Undisturbed A**	Replicate Undisturbed B†	Replicate Remolded A**	Replicate Remolded B†	Replicate Undisturbed A**	Replicate Undisturbed B†	Replicate Remolded A**	Replicate Remolded B†	Average Undisturbed B†	Average Remolded B†
(200,50)	22.9	5.0	103	0.2	6	4.1	84	0.8	23	5.4	114	0.5	14	100.3	14.3
	45.7	5.2	107	1.2	35	4.0	82	1.5	34	5.8	122	1.4	32	103.7	33.7
(250,450)	22.9	2.5	58	0.7	20	2.9	64	1.1	31	--	--	--	--	61	25.5
	53.3	5.6	114	0.7	20	5.9	120	1.9	43	--	--	--	--	117	31.5
(300,475)	12.7	10.1	205	2.7	60	12.0	243	1.9	43	--	--	--	--	224	51.5
	22.9	11.8	239	4.0	81	--	--	--	--	--	--	--	--	239	81
(500,475)	22.9	3.5	75	1.1	26	3.8	77	0.9	26	--	--	--	--	76	26
	36	3.8	77	1.1	26	4.0	84	1.2	31	--	--	--	--	81	29
(600,35)	22.9	6.3	131	1.1	26	5.8	120	1.3	37	6.1	128	1.0	26	126	30
(600,75)	22.9	1.0	28	0.1	3	--	--	--	--	--	--	--	--	28	3
	53.3	1.9	44	0.3	9	--	--	--	--	--	--	--	--	44	9
	83.8	3.3	71	0.8	23	--	--	--	--	--	--	--	--	71	23
	114.3	4.8	99	1.2	34	--	--	--	--	--	--	--	--	99	34
	132.2	7.3	151	1.7	39	--	--	--	--	--	--	--	--	151	39
(600,100)	22.9	0.5	14	0.1	3	0.7	20	0.4	11	0.5	14	0.2	6	16	6.7
	53.3	1.0	28	0.5	14	1.3	37	0.2	6	1.3	37	0.3	8.5	34	9.5
	83.8	2.1	49	0.2	6	2.1	49	0.4	11	2.2	51	0.5	14	49.7	10.3
	114.3	4.2	86	1.7	39	2.9	64	0.9	26	5.3	109	1.2	34	86.3	33
	142.2	5.8	122	0.7	20	5.0	102	0.5	14	6.0	126	0.9	26	116.7	20
(600,250)	22.9	0.1	3	0	0	0.1	3	0	0	0.1	3	0	0	3	0
	53.3	0.5	14	0.2	6	0.9	26	0.2	6	0.8	23	0.2	6	21	6
	83.8	1.7	41	0.3	9	3.1	68	0.3	9	1.6	38	0.5	15	49	11
	114.3	2.9	64	1.0	28	2.0	47	0.5	14	2.3	54	0.3	9	55	17
	142.2	5.4	111	0.5	14	4.9	100	0.8	23	4.5	92	0.7	20	101	19
(1100,150) Site AS	22.9	0.7	20	0.3	9	0.8	23	0.2	6	0.8	23	0.2	6	22	7
	53.3	1.8	43	0.5	14	1.5	36	0.6	17	1.7	41	0.3	9	40	13.3
	83.8	3.3	73	0.2	6	1.1	31	0.4	11	1.7	41	1.0	28	48.3	15
	114.3	4.2	86	0.8	23	4.1	84	0.6	17	4.1	84	0.8	23	84.7	21
	139.7	4.3	88	0.9	26	4.1	84	0.8	23	4.9	100	0.8	23	90.7	24
(1100,350)	22.9	2.5	55	0.2	6	0.6	17	0.4	11	0.9	26	0.2	6	32.7	7.7
	53.3	1.6	38	0.3	9	1.5	33	0.6	17	2.9	64	0.6	17	45	14.3
	58.4	--	--	--	--	--	--	--	--	10.6	216	1.0	28	216	28
	76.2	--	--	--	--	9.0	190	1.1	31	--	--	--	--	190	31

(continued)

Table B'28 (Concluded)

Location* (x,y)	Depth (cm)	Undisturbed A**	Undisturbed B†	Remolded A**	Remolded B†	Replicate Undisturbed A**	Replicate Undisturbed B†	Replicate Remolded A**	Replicate Remolded B†	Replicate Undisturbed A**	Replicate Undisturbed B†	Replicate Remolded A**	Replicate Remolded B†	Average Undisturbed B†	Average Remolded B†
(1200,100)	22.9	1.0	28	0.1	3	1.0	28	0.8	23	1.6	38	1.4	40	31.3	22
	53.3	2.8	62	0.7	20	2.8	62	1.0	28	4.5	92	1.0	28	72	25.3
	83.8	7.5	155	1.2	34	10.7	218	1.7	38	5.7	115	1.5	36	162.7	36
	114.3	5.3	109	0.9	26	6	126	1.0	28	5.8	118	0.8	23	117.7	24.5
	138	5.8	122	0.9	26	5.4	110	0.9	26	5.5	112	0.4	11	114.7	21
(1400,326)	22.9	4.0	82	0.7	20	2.3	54	1.0	28	--	--	--	--	68	24
	53.3	2.1	49	0.1	3	1.6	38	0.5	14	--	--	--	--	43.5	8.5
	83.8	6.2	130	1.3	37	7.1	145	1.4	34	--	--	--	--	137.5	35.5
	114.3	7.2	147	1.3	37	6.9	141	1.4	34	--	--	--	--	144	35.5
	142.2	7.8	159	1.8	43	8.0	164	1.8	43	--	--	--	--	161.5	43
(1400,445)	22.9	18.8	384	3.3	71	20.0	409	3.0	66	24.8	512	0.5	14	435	50
	53.3	20.6	422	3.4	74	7.1	158	0.9	26	--	--	--	--	290	50

Summary Statistics for various depths

	Depth (cm)	Undisturbed lb/ft**		Remolded lb/ft**	Undisturbed g/cm**	Remolded g/cm**
Mean	22.4	117	n = 26	30	57.1 ± 54.7	14.6 ± 11.2
Standard deviation	± 2.3	± 112		± 23		
Mean	51.8	117	n = 20	31	57.1 ± 44.4	15.1 ± 9.8
Standard deviation	± 4.2	± 91		± 20		
Mean	83.0	101	n = 10	27	49.3 ± 33.2	13.2 ± 8.3
Standard deviation	± 2.4	± 68		± 17		
Mean	114.3	122	n = 9	33	51.6 ± 43.9	16.1 ± 7.8
Standard deviation	± 0	± 90		± 16		
Mean	140.4	134	n = 9	32	65.4 ± 43.5	15.6 ± 8.8
Standard deviation	± 3.6	± 89		± 18		
Total of all 74 analysis						
Mean	65	118		30	57.6	14.6
Standard deviation	± 42	± 9		± 2	± 4.4	± 1.0

* Locations are in feet; see Figure 2 in Volume I for coordinates. High marsh (AH) was located at coordinates 100,400; intertidal was at 250,300; subtidal was at 1100,150.

** A is vane tester reading in Kpa

† B is shear stress in lb/ft_2

Table B'29

Liquid and Plastic Limits (Atterberg Limits) of Sediment at the James River Artificial Habitat Development Site, July 1975

Core Number	Location* (x,y)	Depth (cm)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
FJR-1	(100,150)	4.5	63	32	31**
		92	76	47	39
		98	29	too sandy	N.P.†
		110.5	64	39	25**
		163	55	29	26**
FJR-2	(250,450)	1.5	75	47	28
		50.5	56	35	21
		58	--	too sandy	N.P.
		77	57	34	23
FJR-3	(1100,350)	3	84	45	39
		41.5	55	35	20
FJR-4	(250,300)	4	79	43	36
		64	--	too sandy	N.P.
		71	53	36	17
		80	56	37	19
		103	73	38	35
FJR-5	(100,400)	7	--	too sandy	N.P.
		38	56	31	25
		49	--	too sandy	N.P.
		55	--	too sandy	N.P.
FJR-7	(600,250)	2	73	34	39**
		58	81	37	44**
		64	58	39	19
		72	74	42	32
		124	62	31	31
FJR-8	(1400,450)	25	--	too sandy	N.P.
		79	--	too sandy	N.P.
		107	--	too sandy	N.P.
		119	36	49	N.P.
FJR-10	(1100,150)	6	69	44	25
		49	63	39	24
		57	--	too sandy	N.P.
		102	81	43	38
FJR-11	(600,100)	3	62	41	21
		59	72	43	29
		67	63	37	26
		107	69	41	28
FJR-12	(1400,325)	8	--	too sandy	N.P.
		52	--	too sandy	N.P.
		63	--	too sandy	N.P.
		72	--	too sandy	N.P.
		75	--	too sandy	N.P.
		111	88	43	45
Summary Statistics for Above					
Mean			65	39	29
Standard Deviation			13	5	8
			n = 29	n = 28	n = 27

* Location coordinates are in feet starting with (0,0) in SW corner of the Development Site

** Determination by one-point method. All others were determined by three-point method

† N.P. is nonplastic

Table B'30

Data Collected During the Field Coring Program at the James River Artificial Habitat Development Site and a Reference Marsh, August 6 and 7, 1976

Core No.*	Location	Core Length (cm)	Time	Date	Sediment Temperature (°C) Top	Sediment Temperature (°C) Bottom	Air Temperature (°C)	Tidal Phase
RH1	Outside of reference marsh upland two meters from trees	46	1115 hr	8/7	24.1	22.2	26.6	One hour into flood
RH2	Outside of reference marsh upland two meters from trees	38	1115 hr	8/7	23.9	22.3	26.6	One hour into flood
RH3	Outside of reference marsh upland two meters from trees	46	1115 hr	8/7	24.2	21.6	26.6	One hour into flood
RI1	Reference marsh <30 meters west of small tidal channel RS	21	1240 hr	8/6	27.3**	25.8	30.5	High slack
RI2	Reference marsh <30 meters west of small tidal channel RS	39	1240 hr	8/6	27.3**	26.0	30.5	High slack
RI3	Reference marsh <30 meters west of small tidal channel RS	57	1240 hr	8/6	27.3**	25.0	30.5	High slack
RS1	Middle of reference marsh	84	1130 hr	8/6	25.2 26.7**	21.0	30.2	High slack
RS2	Middle of reference marsh	81	1130 hr	8/6	25.2	22.0	30.2	High slack
RS3	Middle of reference marsh	78	1130 hr	8/6	25.2	22.3	30.2	High slack
AH1	Artificial high marsh x,y = (100,400) (upland)	45	1900 hr	8/6	24.2	22.8	28.8	Low slack
AH2	Artificial high marsh x,y = (100,400) (upland)	50	1900 hr	8/6	24.5	22.5	28.8	Low slack
AH3	Artificial high marsh x,y = (100,400) (upland)	36	1900 hr	8/6	23.2	22.4	28.8	Low slack
AI1	Artificial intertidal marsh x,y = (250,300)	72	1830 hr	8/6	24.1	21.0	29.8	Low slack
AI2	Artificial intertidal marsh x,y = (250,300)	88	1830 hr	8/6	23.8	21.4	29.8	Low slack
AI3	Artificial intertidal marsh x,y = (250,300)	91	1830 hr	8/6	23.5	20.5	29.8	Low slack
AS1	Artificial subtidal marsh x,y = (1100,150)	44	1850 hr	8/6	25.1	22.6	31.8	Low slack
AS2	Artificial subtidal marsh x,y = (1100,150)	80	1850 hr	8/6	25.7	21.1	31.8	Low slack
AS3	Artificial subtidal marsh x,y = (1100,150)	65	1850 hr	8/6	25.0	22.7	31.8	Low slack

* R = reference marsh, A = development site, H = high marsh, I = intertidal marsh, S = subtidal marsh

** Water temperature because sediment was covered by water

Table B'31

Data for Sediment pH, Temperature (°C), Redox Potential (Eh in mV), Water Content (%), and Volatile Solids (%) for August 1976

Code*	pH	T	Eh**	H_2O	VS
AH1 05	6.55	24.2	372.0	45.3	11.6
AH1 17	6.65	******†	91.0	******	******
AH1 35	6.80	22.8	82.0	27.4	3.5
AH2 05	6.83	24.5	456.0	43.1	8.8
AH2 17	6.22	******	181.0	******	******
AH2 37	6.50	22.5	82.0	19.8	1.3
AH3 05	6.12	23.2	******	******	******
AH3 17	******	******	******	******	******
AH3 31	6.65	22.4	8.0	25.9	0.6
AI1 05	6.86	24.1	45.0	57.9	7.9
AI1 17	6.62	******	79.0	******	******
AI1 37	6.56	21.0	72.0	53.3	7.9
AI2 05	6.12	23.8	60.0	59.7	8.1
AI2 17	6.54	******	54.0	******	******
AI2 37	6.37	21.4	42.0	53.3	9.4
AI3 05	6.65	23.5	88.0	65.0	7.7
AI3 17	6.54	******	56.0	******	******
AI3 37	6.47	20.5	64.0	50.2	9.0
AS1 05	6.30	25.1	126.0	55.7	8.2
AS1 17	6.61	******	64.0	******	******
AS1 35	6.98	22.6	92.0	47.5	7.9
AS2 05	6.91	25.7	94.0	58.9	9.3
AS2 17	6.75	******	80.0	******	******
AS2 37	7.90	21.1	128.0	53.3	11.1
AS3 05	6.42	25.0	86.0	63.2	9.5
AS3 17	6.46	******	76.0	******	******
AS3 37	6.40	22.7	45.0	19.4	1.1
RH1 05	5.75	24.1	164.0	81.3	25.4
RH1 17	5.47	******	176.0	******	******
RH1 35	5.51	22.2	160.0	68.3	19.4
RH2 05	6.15	23.9	148.0	84.5	10.6
RH2 17	5.75	******	169.0	******	******
RH2 31	5.90	22.3	179.0	66.5	15.4
RH3 05	6.60	24.2	140.0	77.2	27.0
RH3 17	5.63	******	153.0	******	******
RH3 35	5.52	21.6	167.0	71.3	19.5
RI1 10	5.63	27.3	211.0	53.4	10.7
RS1 17	******	******	132.0	******	******
RS1 37	******	25.8	******	62.4	14.7
RI2 05	5.77	27.3	158.0	48.9	8.3
RI2 17	5.81	******	136.0	******	******
RI2 32	******	26.0	111.0	49.7	10.0
RI3 05	6.90	27.3	259.0	55.7	11.1
RI3 17	6.32	******	120.0	******	******
RI3 37	6.24	25.0	132.0	40.3	9.0
RS1 05	6.54	25.2	64.0	73.1	10.1
RS1 17	6.73	******	75.0	******	******
RS1 37	6.41	21.0	72.0	75.4	29.1
RS2 05	6.52	25.7	72.0	78.3	11.1
RS2 17	6.59	******	74.0	******	******
RS2 37	6.30	22.0	80.0	58.3	13.8
RS3 05	7.05	25.2	51.0	90.7	11.9
RS3 17	6.73	******	52.0	******	******
RS3 37	6.65	22.3	66.0	65.0	15.9

*Code

A = Artificial Habitat Development Site, 9 cores

R = Reference marsh, 9 cores

I = Intertidal marsh

S = Subtidal marsh

H = High marsh

1-3 = Replicate core numbers at each location; mean depth (05 cm, 17 cm, etc.) for surface, mid-depth, and deep intervals of cores

**Eh = Average redox potential for two platinum electrodes connected to a common calomel; corrected for SCE (+254 mV)

†****** = No data

Table B-32

Data for Sediment Interstitial (mg/l) and Total (μg/g) Nutrients and Carbon for August 1976

CODE*	PO_4	TDP	TP	NH_4	$NO_3 + NO_2$	CODE	TDN	TKN	DOC	TC
AH1 05	******	******	275.	******	******	AH1 05	******	204.	******	7805.
AH1 17	******	******	491.	******	******	AH1 17	******	332.	47.3	12358.
AH1 35	0.100	0.119	1260.	1.90	0.100	AH1 35	12.84	474.	27.7	11187.
AH2 05	******	0.133	499.	******	******	AH2 05	3.14	215.	19.0	12317.
AH2 17	******	******	817.	******	******	AH2 17	******	450.	74.9	11706.
AH2 37	******	******	712.	******	******	AH2 37	******	474.	27.5	10157.
AH3 05	0.117	******	270.	******	0.117	AH3 05	******	354.	21.6	6808.
AH3 17	******	******	237.	0.58	******	AH3 17	******	551.	19.5	7574.
AH3 31	******	0.133	509.	0.94	******	AH3 31	4.24	551.	33.8	11102.
AI1 05	0.120	******	756.	******	0.120	AI1 05	******	404.	21.6	8405.
AI1 17	0.099	0.118	912.	2.97	0.099	AI1 17	13.74	952.	75.5	7527.
AI1 37	0.067	0.156	900.	5.14	0.067	AI1 37	24.14	479.	33.4	13520.
AI2 05	0.120	0.100	1210.	1.71	0.120	AI2 05	8.14	532.	21.6	13275.
AI2 17	0.092	0.235	811.	6.27	0.092	AI2 17	24.34	1004.	21.8	12701.
AI2 37	******	******	1054.	******	******	AI2 37	******	644.	33.1	13805.
AI3 05	0.107	******	295.	******	0.107	AI3 05	******	779.	32.0	10203.
AI3 17	0.104	0.096	772.	0.63	0.104	AI3 17	7.14	1181.	34.9	9935.
AI3 37	0.075	0.136	489.	2.39	0.075	AI3 37	13.24	878.	28.4	8326.
AS1 05	0.103	0.133	916.	0.68	0.103	AS1 05	3.34	967.	35.4	7713.
AS1 17	0.083	0.170	792.	1.76	0.083	AS1 17	13.84	903.	52.5	8326.
AS1 35	0.086	0.271	604.	3.75	0.086	AS1 35	20.54	810.	29.6	9804.
AS2 05	******	0.123	962.	0.80	******	AS2 05	4.24	1253.	20.2	9358.
AS2 17	0.100	0.111	1120.	2.99	0.100	AS2 17	7.34	1411.	61.3	11157.
AS2 37	0.063	0.117	1070.	4.71	0.063	AS2 37	15.44	1386.	41.9	10874.
AS3 05	0.115	0.112	950.	1.04	0.115	AS3 05	1.34	1259.	32.2	12517.
AS3 17	0.125	0.090	1100.	3.84	0.125	AS3 17	20.54	1185.	40.9	10906.
AS3 37	0.092	0.096	301.	5.87	0.092	AS3 37	27.74	604.	48.9	11805.
RH1 05	0.040	0.115	616.	1.51	0.155	RH1 05	2.79	1864.	16.0	9500.
RH1 17	0.040	0.114	290.	0.51	0.229	RH1 17	2.05	1976.	19.0	12063.
RH1 35	******	******	94.	******	******	RH1 35	******	434.	41.9	7822.
RH2 05	0.042	0.123	419.	0.71	0.125	RH2 05	1.54	1247.	79.1	13320.
RH2 17	0.067	0.122	400.	0.65	0.122	RH2 17	1.75	431.	19.0	14950.
RH2 31	******	******	65.	******	******	RH2 31	******	464.	43.7	11231.
RH3 05	******	0.096	193.	******	******	RH3 05	2.56	2002.	31.2	11229.
RH3 17	0.049	0.110	555.	0.77	0.160	RH3 17	0.19	1636.	23.2	10357.
RH3 35	0.047	0.115	315.	0.42	0.213	RH3 35	4.24	1035.	14.0	10001.
RI1 10	0.051	0.101	691.	0.34	0.126	RI1 10	0.92	1763.	35.3	11887.
RI1 17	******	******	******	******	******	RI1 17	******	******	******	******
RI1 37	******	******	******	******	******	RI1 37	******	******	******	******
RI2 05	0.054	0.370	416.	0.72	0.145	RI2 05	1.54	615.	37.3	8817.
RI2 17	******	0.131	463.	0.36	******	RI2 17	2.27	762.	26.1	10526.
RI2 32	******	******	507.	******	******	RI2 32	******	813.	20.1	15404.
RI3 05	0.056	0.207	557.	0.56	0.111	RI3 05	31.54	482.	21.3	10094.
RI3 17	0.056	0.159	604.	1.20	0.072	RI3 17	25.39	681.	32.6	15109.
RI3 37	******	******	646.	******	******	RI3 37	******	596.	20.1	12257.
RS1 05	0.068	0.131	1250.	2.49	0.090	RS1 05	13.74	2543.	19.4	12453.
RS1 17	0.065	0.160	1100.	3.62	0.002	RS1 17	10.92	2840.	20.5	10527.
RS1 37	0.071	0.370	234.	3.92	0.003	RS1 37	20.62	1247.	23.9	17737.
RS2 05	0.063	0.230	1240.	1.20	0.100	RS2 05	19.66	2579.	15.7	9854.
RS2 17	0.066	0.237	1160.	1.79	0.066	RS2 17	11.13	2177.	19.0	13005.
RS2 37	0.064	0.213	1610.	3.34	0.066	RS2 37	19.46	2604.	50.7	16617.
RS3 05	0.071	0.159	996.	1.51	0.109	RS3 05	22.37	2090.	23.5	12416.
RS3 17	0.070	0.184	967.	2.96	0.119	RS3 17	12.40	2463.	21.0	11203.
RS3 37	0.069	0.236	1000.	3.12	0.064	RS3 37	8.21	2312.	24.0	10895.

* Code

A = Artificial Habitat Development Site, 9 cores

R = Reference marsh, 9 cores

H = High marsh

I = Intertidal marsh

S = Subtidal marsh

1-3 = Replicate core numbers at each location; mean depth (05 cm, 17 cm, etc.) for surface, mid-depth, and deep intervals of cores

****** = No data

PARAMETER

PO_4 = Dissolved Orthophosphate
TDP = Total Dissolved Phosphorus
TP = Bulk Phosphorus
NH_4 = Dissolved Ammonium

TDN = Total Dissolved Nitrogen
TKN = Bulk Kjeldahl Nitrogen
DOC = Dissolved Organic Carbon
TC = Total Organic Carbon

$NO_3 + NO_2$ = Dissolved Nitrate plus Nitrite

Table B'33

Data for Sediment Interstitial Metals (mg/l) for August 1976

Code*	Ca	Cr	Cu	Fe	Code	Hg**	Mn	Zn
AH1 05	******	******	******	******	AH1 05	******	******	******
AH1 12	40.40	0.051	******	7.70	AH1 17	******	3.15	0.192
AH1 35	86.40	******	0.019	26.60	AH1 35	2.981	2.30	0.034
AH2 05	******	******	******	******	AH2 05	******	******	******
AH2 12	65.60	0.032	******	10.20	AH2 12	2.752	7.13	0.025
AH2 37	84.00	0.031	0.013	17.30	AH2 37	******	4.10	0.025
AH3 05	******	******	******	******	AH3 05	******	******	******
AH3 17	******	******	******	******	AH3 24	22.20	******	******
AH3 31	42.80	******	0.039	3.42	AH3 37	******	1.19	0.295
AI1 05	37.00	0.034	******	15.20	AI1 05	******	3.36	0.060
AI1 17	72.10	******	0.013	31.90	AI1 17	2.341	3.75	0.003
AI1 37	105.00	******	0.018	38.70	AI1 37	7.030	3.24	0.012
AI2 05	******	******	******	******	AI2 05	******	******	******
AI2 12	40.50	******	0.020	17.70	AI2 12	14.372	2.62	0.027
AI2 37	85.30	******	0.015	31.70	AI2 37	4.270	2.69	0.051
AI3 05	47.90	******	0.025	29.40	AI3 05	******	6.16	0.129
AI3 17	96.10	******	0.018	32.60	AI3 17	2.446	5.44	0.087
AI3 37	110.00	******	0.032	43.00	AI3 37	1.525	3.61	0.082
AS1 05	74.50	0.036	0.018	66.10	AS1 05	6.573	5.02	0.025
AS1 17	120.00	******	0.023	62.20	AS1 17	2.255	4.89	0.025
AS1 35	92.40	******	0.015	45.40	AS1 37	3.314	3.52	0.012
AS2 05	******	******	******	******	AS2 05	2.621	******	******
AS2 17	82.60	******	0.050	31.20	AS2 17	2.837	3.01	0.074
AS2 37	117.00	******	0.018	46.20	AS2 37	2.292	3.82	0.096
AS3 05	******	******	******	******	AS3 05	12.162	******	******
AS3 17	100.00	0.022	0.137	29.40	AS3 17	6.511	3.34	0.034
AS3 37	131.00	******	0.022	28.00	AS3 37	1.713	4.05	0.021
RH1 05	******	******	******	******	RH1 05	******	******	******
RH1 12	19.00	0.027	0.016	1.86	RH1 12	10.060	0.62	0.122
RH1 35	5.18	0.027	******	4.09	RH1 37	1.788	0.20	0.043
RH2 05	******	******	******	******	RH2 05	******	******	******
RH2 12	11.20	0.057	******	6.10	RH2 12	4.476	0.54	0.056
RH2 31	8.89	0.060	******	10.50	RH2 31	4.500	0.41	0.104
RH3 05	13.90	******	******	6.56	RH3 05	******	0.47	0.047
RH3 17	8.21	0.032	******	5.82	RH3 12	4.865	0.28	0.082
RH3 33	5.86	0.035	******	6.56	RH3 33	2.286	0.27	0.100
RI1 10	11.90	0.024	0.021	25.40	RI1 10	3.350	0.87	0.091
RI1 17	******	******	******	******	RI1 17	******	******	******
RI1 37	******	******	******	******	RI1 37	******	******	******
RI1 05	******	******	******	******	RI2 05	******	******	******
RI2 12	9.56	******	******	15.50	RI2 12	6.954	0.88	0.043
RI2 32	15.30	0.028	******	46.40	RI2 32	2.120	1.03	0.025
RI3 05	******	******	******	******	RI3 05	******	******	******
RI3 12	13.60	0.023	******	23.10	RI3 12	6.709	0.83	0.047
RI3 37	13.30	******	0.133	56.60	RI3 37	1.990	1.22	0.091
RS1 05	53.70	******	0.034	51.90	RS1 05	1.730	3.36	0.131
RS1 17	49.60	******	0.023	66.60	RS1 17	1.097	2.67	0.184
RS1 37	42.20	******	******	75.40	RS1 37	2.320	1.37	0.131
RS2 05	52.00	******	******	30.70	RS2 05	2.706	3.64	0.025
RS2 17	52.70	******	******	56.50	RS2 17	2.074	3.10	0.060
RS2 37	41.50	******	******	66.60	RS2 37	2.909	1.25	0.016
RS3 05	39.50	******	******	16.00	RS3 05	2.026	2.41	0.030
RS3 17	49.30	******	******	58.30	RS3 17	10.794	2.90	0.119
RS3 37	40.50	******	******	69.90	RS3 37	5.065	1.86	0.029

* Code

A = Artificial Habitat Development Site, 9 cores

R = Reference marsh, 9 cores

H = High marsh

I = Intertidal marsh

S = Subtidal marsh

1-3 = Replicate core numbers at each location; mean depth (05 cm, 17 cm, etc.) for surface, mid-depth, and deep intervals of cores

****** = No data

** Mercury (Hg) units are ug/l

Table B'34

Data for Total Sediment Metals (μg/g) for August 1976

Code*	Ca	Cd	Cr	Cu	Fe	Code*	Hg	Mn	Ni	Pb	Zn
AH1 05	1870.	0.72	26.5	26.3	20780.	AH1 05	0.236	560.	18.6	32.3	126.
AH1 17	1950.	0.71	27.1	22.0	21870.	AH1 17	0.143	656.	19.4	29.6	113.
AH1 37	******	******	******	******	******	AH1 37	******	******	******	******	******
AH2 05	2420.	0.80	26.1	18.8	23700.	AH2 05	0.095	548.	18.5	29.1	108.
AH2 16	2270.	0.80	26.8	19.8	23920.	AH2 16	0.092	571.	18.6	28.1	112.
AH2 37	******	******	******	******	******	AH2 37	******	******	******	******	******
AH3 05	2300.	0.92	26.4	24.1	23970.	AH3 05	0.175	672.	19.1	37.6	116.
AH3 18	3010.	1.21	34.8	31.3	30930.	AH3 18	0.125	786.	23.8	46.4	155.
AH3 37	******	******	******	******	******	AH3 37	******	******	******	******	******
AI1 05	3040.	1.58	39.6	37.4	36340.	AI1 05	0.216	783.	31.2	54.6	170.
AI1 17	3680.	1.66	47.0	40.1	41160.	AI1 17	0.235	984.	36.8	69.4	221.
AI1 32	3770.	1.57	44.5	43.7	38750.	AI1 32	0.220	1020.	36.8	66.3	203.
AI2 05	3440.	1.67	45.4	46.6	39070.	AI2 05	0.233	884.	34.0	68.4	217.
AI2 17	3790.	2.12	50.4	55.6	44280.	AI2 17	0.235	1080.	42.4	80.6	254.
AI2 37	3230.	1.38	40.3	47.3	36460.	AI2 37	0.195	954.	30.1	58.6	192.
AI3 05	3100.	1.56	42.6	42.7	37910.	AI3 05	0.325	810.	31.0	60.6	200.
AI3 17	3900.	1.73	45.1	46.9	40320.	AI3 17	0.330	1030.	38.0	67.2	219.
AI3 37	3360.	1.40	37.7	34.9	34770.	AI3 37	0.210	888.	30.4	51.2	176.
AS1 05	3740.	1.88	45.1	40.8	41200.	AS1 05	0.310	938.	38.8	69.5	235.
AS1 17	3780.	1.90	45.2	50.4	42900.	AS1 17	0.300	1040.	39.6	68.2	233.
AS1 37	3280.	1.54	43.2	45.3	39100.	AS1 37	0.260	993.	35.2	62.5	214.
AS2 05	3650.	1.68	47.1	50.2	41050.	AS2 05	0.245	1050.	30.1	68.2	236.
AS2 17	3080.	1.74	51.0	57.4	47160.	AS2 17	0.290	1140.	44.9	80.4	235.
AS2 37	2490.	1.43	49.0	45.2	46920.	AS2 37	0.243	1060.	44.3	77.9	183.
AS3 05	3200.	1.71	35.0	46.5	40810.	AS3 05	0.202	952.	37.7	53.6	221.
AS3 17	2600.	1.16	26.0	27.1	29380.	AS3 17	0.200	785.	24.1	37.8	140.
AS3 37	4300.	2.25	53.8	65.6	45740.	AS3 37	0.430	1090.	47.1	86.8	277.
BH1 05	1820.	1.12	27.0	39.1	32650.	BH1 05	0.210	165.	40.4	56.7	189.
BH1 17	******	1.09	30.0	******	13360.	BH1 17	0.152	******	******	******	170.
BH1 30	1270.	1.12	30.0	39.7	34960.	BH1 30	0.138	197.	46.6	46.6	153.
BH2 05	4480.	1.43	34.0	40.8	30600.	BH2 05	0.203	305.	37.4	69.9	239.
BH2 17	1780.	1.49	28.0	40.9	31040.	BH2 17	0.275	141.	40.5	79.8	153.
BH2 37	1760.	1.08	29.0	34.0	29940.	BH2 37	1.370	179.	45.5	36.4	148.

(continued)

Table B'34 (Concluded)

Code*	Ca	Cd	Cr	Cu	Fe	Code*	Hg	Mn	Ni	Pb	Zn
RH3 05	2900.	1.45	42.8	56.6	35180.	RH3 05	0.250	224.	38.6	84.3	382.
RH3 17	1410.	1.20	34.4	39.9	35880.	RH3 17	0.238	154.	36.8	82.8	184.
RH3 37	1260.	1.06	36.4	32.2	40920.	RH3 37	0.195	243.	39.3	44.4	124.
RI1 05	3590.	2.06	40.2	52.4	51350.	RI1 05	0.270	933.	45.0	71.1	252.
RI1 17	2950.	1.76	36.0	51.9	44780.	RI1 17	0.300	789.	44.3	66.7	235.
RI1 35	1700.	0.91	42.3	30.6	32500.	RI1 35	0.080	283.	41.9	30.4	110.
RI2 05	1980.	1.25	43.2	43.1	40430.	RI2 05	0.213	474.	44.1	52.4	187.
RI2 16	1220.	0.89	43.2	34.5	33520.	RI2 16	0.070	285.	42.2	42.6	129.
RI2 37	******	******	******	******	******	RI2 37	******.	******	******	******	******
RI3 05	1960.	1.15	44.6	42.6	34830.	RI3 05	0.198	330.	43.8	59.3	197.
RI3 17	1560.	1.10	45.3	43.6	36340.	RI3 17	0.280	300.	45.3	52.9	189.
RI3 37	1160.	0.97	43.0	36.1	33910.	RI3 37	0.230	230.	45.7	44.7	128.
RS1 05	3090.	1.73	40.8	54.3	46060.	RS1 05	0.203	737.	43.8	70.7	252.
RS1 17	1870.	0.99	44.4	33.3	26780.	RS1 17	0.120	253.	43.5	39.6	124.
RS1 37	2060.	0.89	42.2	27.1	25230.	RS1 37	0.085	251.	38.2	31.9	105.
RS2 05	******	******	******	******	******	RS2 05	******	******	******	******	******
RS2 12	2180.	1.43	50.9	57.0	38050.	RS2 12	0.206	369.	46.0	71.2	304.
RS2 37	1920.	0.89	42.4	27.0	25020.	RS2 37	0.060	231.	39.3	36.9	108.
RS3 05	2470.	1.79	51.7	63.1	40580.	RS3 05	0.270	500.	46.0	74.5	314.
RS3 17	1770.	0.98	45.9	30.3	30750.	RS3 17	0.090	293.	44.2	38.6	147.
RS3 37	2180.	1.13	46.1	20.0	30000.	RS3 37	0.060	291.	47.6	33.3	130.

* Code

A = Artificial Habitat Development Site, 9 cores

R = Reference marsh, 9 cores

H = High marsh

I = Intertidal marsh

S = Subtidal marsh

1-3 = replicate core numbers at each location; mean depth (05 cm, 17 cm, etc.) for surface, mid-depth, and deep intervals of cores

****** = No data

Table B'35

Sediment Size Parameters for Sediment Cores Collected from the Reference Marsh, James River in August 1976

Core Number and Location*	Core Section and Depth Interval (cm)	Mean Size (φ)	Sorting Coefficient (φ)	Skewness	Kurtosis	Sand (%)	Silt (%)	Clay (%)	Modes (φ)			
									1	2	3	4
RH-1	U 0 - 10	6.9835	4.2032	-0.0516	-0.6413	30.54	24.64	44.82	1.33	7.75	2.52	4.7
RH-1	M 10 - 24	9.6820	2.4771	-0.2340	0.4292	1.93	24.8	73.27	8.08			
RH-1	L 24 - 50	9.1353	3.0948	-0.4455	0.5505	6.59	28.01	65.41	7.73	0.63	5.30	
RH-2	U 0 - 10	6.8823	4.3775	-0.0597	-0.6812	30.98	22.18	43.84	1.17	7.69	5.39	
RH-2	M 10 - 24	9.3846	2.5482	-0.2683	0.6994	2.32	28.38	69.3	7.98			
RH-2	L 29 - 38	8.6202	3.3184	-0.3835	0.2635	9.92	32.16	57.92	7.59	1.73		
RH-3	U 0 - 10	6.8636	4.4627	-0.0724	-0.6983	33.70	19.17	47.13	1.23	7.97	5.20	
RH-3**	M 10 - 24	9.6365	2.5026	-0.2608	0.5267	2.04	25.07	72.89	7.0 to 9.0			
RH-3**	M 10 - 24	9.6361	2.5040	-0.2635	0.5397	2.04	25.07	72.89	7.0 to 9.0			
RH-3	L 24 - 50	8.6718	3.4097	-0.3572	0.1161	9.20	32.27	58.54	7.53	0.79		
RI-1	U 0 - 10	9.1106	2.5771	0.0064	-0.1531	1.39	39.68	58.94	7.38			
RI-1	M 10 - 24	9.2805	2.5801	-0.0087	-0.2995	1.05	37.23	61.72	7.44			
RI-2†	U 0 - 10											
RI-2	M 10 - 24	9.0130	2.7207	0.0289	-0.4094	1.03	42.61	56.36	6.98			
RI-2	L 24 - 50	8.9498	3.1420	-0.4585	0.8686	4.96	34.55	60.48	7.55			
RI-3	U 0 - 10	8.6382	3.6579	-0.5188	0.5598	9.19	30.13	60.68	-2.49	7.76	0.61	
RI-3	M 10 - 24	8.9404	2.5129	-0.0574	0.2078	1.90	39.38	58.73	7.47	9.25		
RI-3	L 24 - 50	9.4584	2.6052	-0.1054	-0.1411	1.32	32.92	65.76	7.62	4.75		
RS-1	U 0 - 10	9.2537	2.5872	0.0263	-0.4117	0.52	38.39	61.08	7.33	4.77		
RS-1	M 10 - 24	9.4117	2.5106	0.0215	-0.4385	0.58	35.06	64.36	7.54			
RS-1	L 24 - 50	9.2888	2.5077	0.0461	-0.3824	0.36	38.42	61.23	7.48	4.75		
RS-2	U 0 - 10	10.1987	2.8005	-0.6913	-0.5413	0.23	50.76	49.01	6.74			
RS-2	M 10 - 24	9.3450	2.5164	0.0553	-0.547	0.21	38.24	61.56	6.0 to 8.0			
RS-2	L 24 - 50	8.8365	1.7548	0.1317	0.5830	0.51	31.96	67.53	9.41	7.66		
RS-3	U 0 - 10	8.9338	2.3906	0.2088	-0.3887	0.28	43.13	56.59	7.41	4.77		
RS-3	M 10 - 24	9.5072	2.5317	-0.0109	-0.4709	0.39	33.61	66.0	7.53			
RS-3	L 24 - 50	9.5103	2.5481	-0.0249	-0.4428	0.61	32.82	66.57	7.78	5.96		

* H = high marsh, I = intertidal marsh, S = subtidal marsh; see Figure 3 in Volume I for locations

** Duplicate analysis of different sample aliquots

† Sample lost

Table B'36

Cation Exchange Capacity (NaEC) of Unfractionated Total Sediment Core Samples from the James River Artificial Habitat Development Site and a Reference Marsh for August 1976

	Core Number and Location*	Upper Section (0 - 10 cm) meq /100 g	Lower Section (24 - 50 cm) meq /100 g	Core Number and Location*	Upper Section (0 - 10 cm) meq / 100 g	Lower Section (24 - 50 cm) meq / 100 g
	High Marsh			High Marsh		
	AH1**	7.1	12.3	RH1	83.2	66.5
	AH2	5.6	9.9	RH2	93.3	59.1
	AH3	5.4	7.5	RH3	89.8	59.0
Mean		6.0	9.9		88.8	61.5
Std. Dev.		± 1.0	± 2.4		± 5.2	± 4.3
	Intertidal			Intertidal		
	AI1	41.4	29.1	RI1	61.5	58.1
	AI2	50.8	34.2	RI2	49.0	40.6
	AI3	47.6	35.5	RI3	45.8	47.0
Mean		46.6	33.0		52.1	48.6
Std. Dev.		± 4.8	± 3.4		± 8.3	± 8.8
	Subtidal			Subtidal		
	AS1	43.5	44.0	RS1	61.8	64.8
	AS2	46.2	44.8	RS2	60.5	61.8
	AS3	42.1	41.2	RS3	59.4	68.5
Mean		43.9	43.3		60.6	65.0
Std. Dev.		± 2.1	± 1.9		± 1.2	± 3.4
Total Mean for Above		32.2	28.7		67.2	58.4
Total Std. Dev.		±19.8	±15.0		±17.3	± 9.1

* A = Artificial Habitat Development Site, R = reference marsh

** All cores contained abundant quartz sand which reduced the CEC

Table B'37

Sediment Vane Shear Measurements at the Reference Marsh, James River, in August 1976

	Location	Depth cm	UNDISTURBED Shear Stress g/cm^2		REMOLDED Shear Stress g/cm^2	
			g/cm^2	lb/ft^2	g/cm^2	lb/ft^2
	High Marsh (RH)	8	54	110	31	64
	"		36	73	19	38
	"		37	75	13	26
Mean			42	86.0	21	42.7
Std. Dev.			± 10	± 20.8	±10	±19.4
	High Marsh (RH)	23	138	282	25	51
	"		132	270	15	30
	"		59	120	4	9
	"		106	218	15	30
Mean			218	233	15	30
Std. Dev.			± 36	± 74	± 8	±17
	High Marsh (RH)	53	57	117	11	22
	"		41	84	17	34
	"		131	268	9	19
	"		107	220	7	14
Mean			84	172	11	22
Std. Dev.			± 42	± 86	± 4	± 9
	High Marsh (RH)	84	98	201	11	22
	"		69	141	11	22
	"		131	268	8	17
Mean			99	203	10	20
Std. Dev.			± 31	± 64	± 2	± 3
	High Marsh (RH)	114	69	141	17	34
	"		62	128	19	38
	"		110	226	16	32
Mean			81	165	17	35
Std. Dev.			± 26	± 53	± 2	± 3
	High Marsh (RH)	137	72	148	24	49
	"		84	173	31	64
	"		177	362	24	49
Mean			111	228	26	54
Std. Dev.			± 57	±117	± 4	± 9
	Intertidal Marsh (RI) 58 cm Water Overlying Sediment	23	224	459	11	22
			50	102	13	26
			133	273	11	22
Mean			136	278	11	23
Std. Dev.			± 87	±179	± 1	± 2

(continued)

Table B'37 (Concluded)

Location	Depth cm	UNDISTURBED Shear Stress g/cm²		REMOLDED Shear Stress g/cm²	
		g/cm^2	lb/ft^2	g/cm^2	lb/ft^2
Subtidal Marsh (RS) 64 cm Water Overlying Sediment	15	14	28	7	14
		16	32	4	9
		13	26	0	0
Mean		14	29	4	8
Std. Dev.		± 2	± 3	± 3	± 7
"	43	29	60	8	17
"		35	71	5	11
"		33	68	12	25
Mean		32	66	9	18
Std. Dev.		± 3	± 6	± 3	± 7
"	74	65	134	16	32
"		61	124	8	17
"		62	126	15	30
Mean		62	128	13	26
Std. Dev.		± 2	± 5	± 4	± 8
Mean for All of the Above (n=32)	30	78	160	14	28
Std. Dev.	±54	±50	±102	± 7	±15

Summary Statistics for Various Depths

	Depth (cm)	Undisturbed g/cm^2	Undisturbed lb/ft^2	Remolded g/cm^2	Remolded lb/ft^2
Mean	17	78	159	13	26
Std. Dev.	± 7	±64	±131	± 8	±17
Mean	48	62	127	10	20
Std. Dev.	± 7	±41	± 83	± 4	± 8
Mean	79	81	166	11	23
Std. Dev.	± 7	±28	± 58	± 3	± 6

Table B'38

Data Collected During the Field Coring Program at the James River Artificial Habitat Development Site and a Reference Marsh, January 11 and 12, 1977

Core Number*	Location	Core Length (cm)	Time	Date	Sediment Temperature °C Top	Sediment Temperature °C Bottom	Air Temperature °C	Tidal Phase
RH1	High marsh	36	1545 hr	1/12	1	4	0	Midflood
RH2	High marsh	61	1550 hr	1/12	1	5	0	Midflood
RH3	High marsh	102	1600 hr	1/12	1	13	0	Midflood
RI1	Adjacent to bank of tidal channel	46	1645 hr	1/12	2	7	-1	Midflood
RI2	Adjacent to bank of tidal channel	22	1655 hr	1/12	3	5	-1	Midflood
RI3	Adjacent to bank of tidal channel	66	1710 hr	1/12	2	8	-1	Midflood
RS1	Adjacent to bank of tidal channel	46	1430 hr	1/12	2	7	-1	One hour into flood
RS2	Adjacent to bank of tidal channel	85	1440 hr	1/12	1	11	-1	One hour into flood
RS3	Adjacent to bank of tidal channel	88	1455 hr	1/12	1	12	-1	One hour into flood
AH1	(100,400)	25	0800 hr	1/12	-8	-4	-5	High tide
AH2	(100,400)	19	0805 hr	1/12	-8	-4	-5	High tide
AH3	(100,400)	25	0810 hr	1/12	-8	-4	-5	High tide
AI1	(250,300)	39	1830 hr	1/11	2	5	3	High tide
AI2	(250,300)	89	1840 hr	1/11	2	10	3	High tide
AI3	(250,300)	115	1850 hr	1/11	2	10	3	High tide
AS1	(1100,150)	98	1600 hr	1/11	0	11	0	Midflood
AS2	(1100,150)	75	1608 hr	1/11	0	13	0	Midflood
AS3	(1100,150)	88	1613 hr	1/11	0	12	0	Midflood

* R = reference marsh, A = development site, H = high marsh, I = intertidal marsh, S = subtidal marsh

Table B'39

Data for Sediment pH, Temperature (°C), Redox Potential (Eh in mV), Water Content (%), and Volatile Solids (%) for January 1977

Code*	pH	Temp.	Eh**	H_2O	VS (%)
AH1 05	6.38	-9.0	472.0	41.2	9.7
AH1 17	6.57	******	115.0	******	******
AH1 37	******	-4.0	******	18.7	0.7
AH2 05	7.10	-8.0	127.0	43.2	5.5
AH2 17	******	******	******	******	******
AH2 37	******	-4.0	******	31.4	2.8
AH3 05	5.76	-9.0	499.0	27.5	3.9
AH3 17	6.24	******	156.0	******	******
AH3 37	******	-4.0	******	27.1	3.1
AI1 05	6.63	2.0	53.0	59.7	9.2
AI1 17	6.71	******	87.0	******	******
AI1 37	6.57	3.0	39.0	46.6	9.1
AI2 05	6.96	2.0	79.0	56.3	9.1
AI2 17	7.03	******	91.0	******	******
AI2 37	6.96	3.0	64.0	38.9	10.2
AI3 05	6.92	2.0	82.0	57.7	9.7
AI3 17	6.99	******	61.0	******	******
AI3 37	6.52	3.0	61.0	43.9	7.5
AS1 05	7.14	-0.2	82.0	60.5	11.9
AS1 17	6.88	******	72.0	******	******
AS1 37	6.95	0.0	100.0	37.8	9.6
AS2 05	6.84	0.0	86.0	54.1	10.7
AS2 17	6.83	******	84.0	******	******
AS2 37	6.80	0.0	127.0	46.0	9.2
AS3 05	6.70	0.0	97.0	43.5	9.1
AS3 17	6.54	******	71.0	******	******
AS3 37	6.71	0.0	114.0	41.5	8.3
RH1 05	5.69	1.5	159.0	76.0	29.4
RH1 17	5.69	******	198.0	******	******
RH1 37	5.76	0.0	197.0	57.1	12.0
RH2 05	6.23	1.5	194.0	82.7	33.0
RH2 17	6.12	******	236.0	******	******
RH2 37	5.75	0.0	193.0	57.0	13.7
RH3 05	6.03	1.5	187.0	79.0	24.9
RH3 17	5.97	******	179.0	******	******
RH3 37	5.93	0.0	184.0	58.9	11.8
RI1 05	5.94	2.0	101.0	73.6	14.7
RI1 17	6.92	******	75.0	******	******
RI1 37	6.26	-1.0	143.0	49.0	9.9
RI2 05	6.33	3.0	133.0	71.1	15.0
RI2 17	6.15	******	173.0	******	******
RI2 37	******	-1.0	******	63.0	14.0
RI3 05	7.35	2.0	248.0	63.1	13.8
RI3 17	7.14	******	179.0	******	******
RI3 37	7.25	-1.0	163.0	38.7	12.8
RS1 05	6.26	1.5	185.0	77.7	14.2
RS1 17	5.53	******	189.0	******	******
RS1 37	5.27	-1.0	214.0	68.6	19.6
RS2 05	6.47	1.0	167.0	82.6	13.9
RS2 17	6.06	******	190.0	******	******
RS2 37	5.87	-1.0	199.0	65.6	18.5
RS3 05	6.79	1.0	96.0	77.4	14.2
RS3 17	6.44	******	98.0	******	******
RS3 37	6.38	-1.0	216.0	70.2	12.8

*Code

A = Artificial Habitat Development Site, 9 cores

R = Reference marsh, 9 cores

H = High marsh

I = Intertidal marsh

S = Subtidal marsh

1-3 = replicate core numbers at each location; mean depth (05 cm, 17 cm, etc.) for surface, mid-depth, and deep intervals of cores

**Eh = Average redox potential for two platinum electrodes connected to a common calomel; corrected for SCE (+254 mV)

****** = No data

Table B'40

Data for Sediment Interstitial (mg/l) and Total (µg/g) Nutrients and Carbon for January 1977

Code*	PO_4	TDP	TP	NH_4	$NO_3 + NO_2$	Code*	TDN	TKN	DOC	TC
AH1 05	******	0.107	477.	******	******	AH1 05	5.25	183.	13.9	11386.
AH1 17	0.108	******	280.	2.16	0.193	AH1 17	******	246.	11.8	13129.
AH1 37	******	******	******	******	******	AH1 37	******	******	******	******
AH2 05	0.072	******	643.	2.50	0.092	AH2 05	******	259.	15.9	12233.
AH2 16	******	******	446.	******	******	AH2 16	******	277.	21.9	13565.
AH2 37	******	******	******	******	******	AH2 37	******	******	******	******
AH3 05	******	******	280.	******	******	AH3 05	******	118.	9.2	11122.
AH3 18	******	******	338.	******	******	AH3 18	******	212.	10.6	13453.
AH3 37	******	******	******	******	******	AH3 37	******	******	******	******
AI1 05	0.066	0.110	987.	1.57	0.095	AI1 05	2.53	424.	10.5	9128.
AI1 17	0.065	0.166	243.	1.90	0.098	AI1 17	1.90	336.	17.5	9326.
AI1 32	0.069	0.134	693.	3.73	0.150	AI1 32	7.07	460.	28.2	15455.
AI2 05	0.074	0.098	1110.	1.65	0.100	AI2 05	1.14	847.	14.2	10916.
AI2 17	0.056	0.186	975.	1.64	0.116	AI2 17	3.23	833.	24.3	16158.
AI2 37	0.262	0.147	774.	3.34	0.193	AI2 37	7.87	455.	20.8	15225.
AI3 05	0.093	0.144	1110.	1.42	0.199	AI3 05	2.97	388.	14.9	12127.
AI3 17	0.079	0.120	442.	2.65	0.072	AI3 17	4.91	662.	25.3	11319.
AI3 37	0.078	0.109	689.	4.22	0.049	AI3 37	7.71	460.	26.9	10524.
AS1 05	0.085	0.160	1300.	2.14	0.109	AS1 05	5.22	1180.	17.7	9805.
AS1 17	0.074	0.131	1140.	5.56	0.115	AS1 17	7.95	535.	17.1	11109.
AS1 37	0.072	0.145	956.	4.64	0.060	AS1 37	8.19	639.	17.5	10757.
AS2 05	******	******	527.	******	******	AS2 05	******	932.	22.6	10034.
AS2 17	0.067	0.147	261.	3.52	0.044	AS2 17	5.73	313.	36.5	12926.
AS2 37	0.072	0.172	743.	2.95	0.034	AS2 37	7.59	1040.	34.0	13457.
AS3 05	0.077	******	894.	1.80	0.071	AS3 05	******	544.	20.6	14685.
AS3 17	0.094	0.125	334.	4.49	0.110	AS3 17	7.43	740.	25.3	11237.
AS3 37	0.082	0.130	963.	4.29	0.115	AS3 37	7.35	656.	21.2	12921.
FH1 05	0.077	0.150	222.	1.52	0.150	FH1 05	1.26	923.	11.7	9884.
FH1 17	0.080	0.146	821.	1.81	0.087	FH1 17	3.34	1120.	14.1	12738.
FH1 30	0.075	******	315.	1.46	0.110	FH1 30	******	1250.	15.3	13415.
FH2 05	******	******	790.	******	******	FH2 05	******	892.	14.2	11219.
FH2 17	0.077	0.160	323.	1.33	0.063	FH2 17	3.13	923.	19.0	13156.
FH2 37	0.074	0.186	693.	3.25	0.093	FH2 37	3.35	433.	13.2	12352.
FH3 05	0.077	******	748.	1.30	0.098	FH3 05	******	1470.	19.0	10103.
FH3 17	0.067	0.147	721.	1.90	0.103	FH3 17	3.22	1690.	16.6	12800.
FH3 37	0.056	0.161	1600.	1.81	0.129	FH3 37	3.53	1100.	18.0	11327.
FI1 05	0.294	0.167	1060.	1.33	0.205	FI1 05	1.26	544.	21.4	9278.
FI1 17	0.086	0.232	1120.	1.59	0.206	FI1 17	4.31	567.	15.8	11029.
FI1 35	0.076	0.194	222.	1.83	0.220	FI1 35	2.03	767.	14.3	12197.
FI2 05	0.076	0.159	898.	2.78	0.057	FI2 05	1.74	709.	13.7	13353.
FI2 16	0.100	0.211	199.	2.15	0.111	FI2 16	3.29	979.	16.6	16715.
FI2 37	******	******	******	******	******	FI2 37	******	******	******	******
FI3 05	0.078	0.189	211.	2.44	0.147	FI3 05	2.45	785.	15.7	10236.
FI3 17	0.093	0.151	450.	1.11	0.075	FI3 17	3.11	1230.	14.1	14061.
FI3 37	0.083	0.201	203.	2.54	0.051	FI3 37	5.27	558.	21.4	11926.
FS1 05	0.093	0.165	875.	1.31	0.057	FS1 05	3.21	1010.	19.0	13021.
FS1 17	0.101	0.134	230.	1.33	0.089	FS1 17	3.84	1510.	18.5	12458.
FS1 37	0.098	0.123	280.	1.46	0.133	FS1 37	4.94	571.	15.9	10524.
FS1 05	******	******	******	******	******	FS1 05	******	******	9.3	******
FS2 12	0.097	0.151	790.	1.75	0.075	FS2 12	4.09	1560.	******	14984.
FS2 37	0.102	0.152	547.	1.35	0.100	FS2 37	4.78	1980.	2.3	15637.
FS3 05	0.063	0.133	1670.	2.36	0.044	FS3 05	4.20	1200.	18.5	14701.
FS3 17	0.067	0.143	423.	1.94	0.027	FS3 17	5.03	749.	24.1	12506.
FS3 37	0.072	0.147	793.	1.51	0.053	FS3 37	5.42	834.	24.5	11152.

* Code

A = Artificial Habitat Development Site, 9 cores

R = Reference marsh, 9 cores

H = High marsh

I = Intertidal marsh

S = Subtidal marsh

1-3 = replicate core numbers at each location; mean depth (05 cm, 17 cm, etc.) for surface, mid-depth, and deep intervals of cores

****** = No data

PARAMETER

PO_4 = Dissolved Orthophosphate
TDP = Total Dissolved Phosphorus
TP = Bulk Phosphorus
NH_4 = Dissolved Ammonium

TDN = Total Dissolved Nitrogen
TKN = Bulk Kjeldahl Nitrogen
DOC = Dissolved Organic Carbon
TC = Total Organic Carbon

$NO_3 + NO_2$ = Dissolved Nitrate plus Nitrite

Table B'41

Data for Sediment Interstitial Metals (mg/l)* for January 1977

Code*	Ca	Fe	Hg**	Mn	Zn
AH1 05	******	******	******	******	******
AH1 17	******	******	******	******	******
AH1 37	******	******	******	******	******
AH2 05	******	******	1.454	******	******
AH2 16	34.80	1.43	******	1.70	0.043
AH2 37	******	******	******	******	******
AH3 05	14.90	1.70	******	0.34	0.025
AH3 17	******	******	******	******	******
AH3 37	******	******	******	******	******
AI1 05	20.00	8.36	0.785	2.66	0.010
AI1 17	70.90	24.32	0.533	3.45	0.022
AI1 37	107.40	36.12	0.048	3.49	0.076
AI2 05	47.90	9.98	0.571	3.60	0.010
AI2 17	76.50	37.04	0.944	3.41	0.036
AI2 37	116.20	41.67	0.375	3.72	0.133
AI3 05	51.00	20.62	0.600	4.54	0.025
AI3 17	******	******	0.500	******	******
AI3 37	116.80	45.60	0.250	3.72	0.065
AS1 05	57.20	25.48	0.800	3.95	0.089
AS1 17	91.80	36.58	1.363	4.14	0.140
AS1 37	99.90	11.14	0.705	2.55	0.085
AS2 05	56.00	16.69	******	2.43	0.104
AS2 17	56.60	28.40	0.722	2.72	0.041
AS2 37	26.10	10.91	0.230	0.48	0.033
AS3 05	27.40	0.96	******	1.20	0.033
AS3 17	******	******	2.900	******	******
AS3 37	94.30	17.15	0.330	2.86	0.022
RH1 05	7.46	0.06	0.736	0.05	0.026
RH1 17	0.71	7.21	0.350	0.42	0.081
RH1 30	4.35	5.13	0.750	0.26	0.081
RH2 05	18.00	0.24	0.727	0.50	0.041
RH2 17	7.46	1.20	0.360	0.23	0.063
RH2 37	6.04	3.29	0.300	0.19	0.044
RH3 05	6.84	3.28	0.666	0.40	0.267
RH3 17	5.60	10.60	0.387	0.36	0.041
RH3 37	8.71	35.42	0.290	0.57	0.033
RI1 05	30.60	6.75	1.093	5.12	0.037
RI1 17	36.70	22.70	0.457	4.66	0.056
RI1 35	21.80	36.81	0.008	2.47	0.037
RI2 05	14.30	1.66	0.920	1.57	0.263
RI2 16	9.33	19.23	0.533	1.30	0.148
RI2 37	******	******	******	******	******
RI3 05	9.95	0.96	0.900	0.78	0.052
RI3 17	5.60	11.83	0.666	0.44	0.037
RI3 37	4.98	12.99	0.450	0.61	0.052
RS1 05	10.00	4.43	0.588	1.08	0.056
RS1 17	11.20	16.23	1.333	0.96	0.063
RS1 37	10.60	15.53	0.500	1.01	0.100
RS2 05	******	******	0.508	******	******
RS2 12	13.10	11.14	******	1.09	0.026
RS2 37	9.95	19.70	0.541	0.99	0.033
RS3 05	19.30	5.36	0.263	1.61	0.022
RS3 17	21.20	32.65	0.625	2.76	0.044
RS3 37	16.50	19.93	0.789	2.00	0.010

* Code

A = Artificial Habitat Development Site, 9 cores

R = Reference marsh, 9 cores

H = High marsh

I = Intertidal marsh

S = Subtidal marsh

1-3 = Replicate core numbers at each location; mean depth (05 cm, 17 cm, etc.) for surface, mid-depth, and deep intervals of cores

****** = No data

** Mercury (Hg) units are µg/l

Table B'42

Data for Total Sediment Metals (μg/g) for January 1977

Code*	Ca	Cd	Cr	Cu	Fe	Code*	Hg	Mn	Ni	Pb	Zn
AH1 05	1060.	0.27	******	9.1	8890.	AH1 05	0.063	200.	7.4	9.6	43.
AH1 17	5590.	0.71	******	17.7	16200.	AH1 17	0.222	555.	14.4	21.9	86.
AH1 35	3100.	1.53	******	46.2	35410.	AH1 35	0.208	1030.	33.9	55.3	207.
AH2 05	******	0.89	33.	28.0	22390.	AH2 05	0.087	643.	17.2	32.3	113.
AH2 17	******	0.71	32.	21.9	19170.	AH2 17	0.213	454.	15.0	27.2	98.
AH2 37	******	0.99	40.	31.6	30420.	AH2 37	0.197	1000.	27.4	40.0	146.
AH3 05	1640.	0.58	******	16.9	14340.	AH3 05	0.065	366.	13.8	20.0	79.
AH3 17	******	0.62	32.	20.7	18920.	AH3 17	0.180	492.	14.7	25.9	90.
AH3 31	2450.	0.89	******	27.2	25740.	AH3 31	0.195	801.	24.0	35.2	144.
AI1 05	******	1.51	66.	47.4	39210.	AI1 05	0.255	934.	34.0	60.8	209.
AI1 17	******	1.76	70.	49.0	41500.	AI1 17	0.245	1080.	36.2	63.3	227.
AI1 37	2880.	1.21	******	37.0	34280.	AI1 37	0.295	963.	32.8	48.5	179.
AI2 05	******	1.75	69.	48.7	41230.	AI2 05	0.195	965.	36.0	63.4	218.
AI2 17	******	1.70	68.	49.7	40800.	AI2 17	0.225	1130.	35.8	63.0	221.
AI2 37	3100.	1.30	******	38.6	34340.	AI2 37	0.213	938.	33.8	48.6	190.
AI3 05	******	1.64	67.	45.2	40390.	AI3 05	0.240	953.	32.9	59.2	215.
AI3 17	******	1.77	71.	49.2	41630.	AI3 17	0.360	1140.	36.9	65.5	232.
AI3 37	******	1.44	64.	46.1	36290.	AI3 37	0.248	1050.	33.2	56.4	209.
AS1 05	******	1.79	72.	55.7	39850.	AS1 05	0.300	1150.	37.4	69.7	246.
AS1 17	******	1.43	60.	45.8	35080.	AS1 17	0.240	1040.	32.9	56.7	211.
AS1 37	******	1.16	68.	44.8	44400.	AS1 35	0.235	1230.	38.2	60.5	174.
AS2 05	******	1.72	66.	49.2	37030.	AS2 05	0.305	951.	35.0	61.8	226.
AS2 17	******	1.79	77.	54.7	43650.	AS2 17	0.355	1220.	37.8	70.2	245.
AS2 37	******	1.80	73.	56.2	43750.	AS2 37	0.385	1190.	38.2	69.4	238.
AS3 05	******	1.67	65.	46.2	38920.	AS3 05	0.240	909.	32.7	62.9	218.
AS3 17	******	2.00	72.	55.4	45350.	AS3 17	0.245	1190.	38.3	72.1	249.
AS3 37	******	1.44	64.	46.1	38840.	AS3 37	0.242	1100.	33.2	60.1	211.
PH1 05	******	0.91	50.	41.1	23500.	PH1 05	0.130	212.	27.0	51.6	152.
PH1 17	6440.	1.04	59.	38.4	28420.	PH1 17	0.230	187.	37.2	53.9	141.
PH1 37	3550.	0.93	50.	31.9	23840.	PH1 35	0.140	208.	33.4	33.6	101.
PH2 05	2870.	0.64	40.	35.5	22250.	PH2 05	0.160	187.	24.2	46.2	168.
PH2 17	3150.	1.15	58.	39.9	26590.	PH2 17	0.141	177.	35.4	67.6	137.
PH2 31	2500.	0.88	63.	33.5	27220.	PH2 31	0.085	214.	34.4	37.6	101.
PH3 05	5360.	1.00	39.	30.9	22300.	PH3 05	0.245	234.	20.9	51.6	165.
PH3 17	5300.	0.82	66.	35.1	30750.	PH3 17	0.112	207.	36.1	41.9	112.
PH3 37	5060.	0.91	58.	32.3	23980.	PH3 35	0.108	220.	33.9	34.2	101.
PI1 10	1800.	1.02	65.	42.3	33130.	PI1 10	0.210	269.	36.2	59.4	230.
PI1 17	******	******	******	******	******	PI1 17	******	******	******	******	******

(continued)

Table B'42 (Concluded)

Code*	Ca	Cd	Cr	Cu	Fe	Code*	Hg	Mn	Ni	Pb	Zn
RI1 37	******	******	******	******	******	RI1 37	******	******	******	******	******
RI2 05	3930.	1.17	63.	28.1	31920.	RI2 05	0.083	307.	38.9	34.6	122.
RI2 17	2250.	0.87	65.	29.9	37340.	RI2 17	0.105	306.	40.2	33.1	117.
RI2 37	1690.	0.90	66.	35.3	46420.	RI2 37	0.105	344.	39.2	37.6	117.
RI3 05	4390.	0.90	63.	34.3	37680.	RI3 05	0.120	282.	36.6	45.0	130.
RI3 17	1930.	1.04	68.	35.3	42790.	RI3 17	0.085	307.	40.9	39.7	128.
RI3 37	1720.	0.82	70.	36.6	44820.	RI3 37	0.090	305.	40.8	37.8	118.
RS1 05	3760.	1.80	76.	73.6	48680.	RS1 05	0.320	473.	40.2	78.7	398.
RS1 17	2900.	0.82	77.	66.3	51590.	RS1 17	0.410	400.	40.1	80.6	564.
RS1 37	3900.	2.05	72.	51.6	54100.	RS1 37	0.300	440.	39.2	69.1	346.
RS2 05	3340.	1.36	78.	65.0	48500.	RS2 05	0.330	539.	41.0	77.3	313.
RS2 17	2890.	1.65	64.	71.8	44270.	RS2 17	0.410	440.	35.6	77.0	136.
RS2 37	2610.	1.83	71.	50.7	60080.	RS2 37	0.310	423.	39.7	69.4	215.
RS3 05	3300.	1.49	77.	71.0	48130.	RS3 05	0.350	496.	40.8	78.0	346.
RS3 17	2640.	1.50	70.	66.0	49040.	RS3 17	0.425	396.	38.1	77.4	535.
RS3 37	2600.	1.65	71.	52.5	55940.	RS3 37	0.305	383.	39.6	78.7	316.

*Code

A = Artificial Habitat Development Site, 9 cores

R = Reference marsh, 9 cores

H = High marsh

I = Intertidal marsh

S = Subtidal marsh

1-3 = replicate core numbers

Mean depth (05 cm, 17 cm, etc.) for surface, mid-depth, and deep intervals of cores

****** = No data

Table B'43

Sodium Cation Exchange Capacity of Unfractionated Total Sediment Core Samples from the James River Artificial Habitat Development Site and a Reference Marsh for January 1977

	Core Number and Location*	Upper Section (0 - 10 cm) meq/100 g	Lower Section (24 - 50 cm) meq/100 g	Core Number and Location*	Upper Section (0 - 10 cm) meq/100 g	Lower Section (24 - 50 cm) meq/100 g
	High Marsh			High Marsh		
	AH1	21.2	15.2	RH1	54.3	44.6
	AH2	16.6	16.5	RH2	118	50.4
	AH3	23.8	27.2	RH3	94.5	44.0
Mean		20.7	19.6		96.0	47.4
Std. Dev.		± 3.1	± 6.6		±30.9	± 3.6
	Intertidal			Intertidal		
	AI1	37.7	34.7	RI1	67.4	37.8
	AI2	40.6	32.3	RI2	43.5	46.0
	AI3	36.9	--	RI3	49.5	43.7
Mean		38.1	33.5		57.0	41.3
Std. Dev.		± 1.8	± 1.7		±12.4	± 5.1
	Subtidal			Subtidal		
	AS1	45.4	41.7	RS1	49.3	53.1
	AS2	29.2	39.7	RS2	43.9	54.7
	AS3	44.6	32.6	RS3	62.0	74.9
Mean		41.1	38.9		50.6	58.9
Std. Dev.		± 8.1	± 4.3		± 8.1	±10.7
Total Mean for the Above		32.9	29.9		64.6	49.9
Total Std. Dev.		±10.6	± 9.8		±25.5	±10.7

* A = development site, R = reference marsh

Table B'44

Changes in Cation Exchange Capacity with Various Treatments for Total Sediment Samples from the James River Artificial Habitat Development Site and a Reference Marsh Collected During January 1977

Sample and Location	CEC Untreated (meq/100 g)	CEC Organic Material Removed (meq/100 g)	Percent Change from Untreated (%)	CEC Organic Material and Iron Coatings Removed (meq/100 g)	Percent Change from Untreated (%)
Development Site					
AH1T**	21.9 20.5	5.6 9.9	-63.5	8.5 8.3	-60.4
AI3T	36.7 37.2	13.1 12.9	-64.8	13.6 13.8	-62.8
AI3B	29.7 26.2	10.6 10.2	-62.8	11.0 13.3	-56.5
AS1T	44.2 46.6	17.5 16.7	-62.4	16.9 17.9	-61.7
AS1B	42.3 41.0	17.0 21.6	-53.7	17.0 16.3	-60.1
Mean	34.6	15.0	-61.4	13.7	-60.3
Std. Dev.	± 9.4	± 3.9	± 4.4	± 3.5	± 2.4
Reference Marsh					
RH2T	127.3 107.9	30.5 28.5	-74.9	23.2 30.5	-77.1
RH2B	50.5 50.4	17.8 17.5	-65.0	19.2 17.3	-63.8
RI1T	66.8 68.1	27.7 23.0	-62.4	24.0 20.5	-67.0
RI1B	34.1 41.4	17.4 22.4	-47.2	17.4 19.3	-51.4
RS1T	45.8 50.8	20.2 20.6	-59.9	16.8 17.9	-65.8
RS1B	53.3 52.8	23.9 23.8	-55.1	22.7 26.4	-53.8
Mean	62.4	22.8	-60.8	21.3	-63.2
Std. Dev.	±27.7	± 4.4	± 9.4	± 4.2	± 9.4

* A = Development Site, R = reference marsh, H = high marsh, I = intertidal marsh, S = subtidal marsh

** T - top = 0 - 10 cm, B - bottom = 24 - 30 cm. Analyses were done in duplicate

Table B'45

Sediment Vane Shear Strength at the James River Artificial Habitat Development Site and a Reference Marsh in January 1977

Development Site

	Location	cm	UNDISTURBED Vane* Reading KPA	UNDISTURBED Shear Stress g/cm²	UNDISTURBED Shear Stress lb/ft²	REMOLDED Vane* Reading KPA	REMOLDED Shear Stress g/cm²	REMOLDED Shear Stress lb/ft²
	(1400,150)	<7.5	5.2	52.2	107.0	1.6	19.5	40.0
			5.0	52.2	107.0	0.2	4.8	10.0
			9.6	96.6	198.0	0.9	12.2	25.0
Mean				67.0	136.0		12.2	25.0
Std. Dev.				± 25.6	± 54.0		± 7.3	±15.0
	(1400,150)	23	12.4	123.5	253.0	2.6	28.3	59.0
			12.9	128.4	263.0	2.4	26.3	55.0
			7.9	79.1	162.0	1.5	13.5	38.0
Mean				±110.3	226.0		24.7	51.0
Std. Dev.				27.2	± 56.0		± 5.4	±11.0
	(1400,150)	53	15.6	155.2	318.0	3.0	32.2	66.0
			11.4	113.7	233.0	2.0	23.4	48.0
			13.2	131.3	269.0	1.6	19.5	40.0
Mean				133.4	273.0		25.0	51.0
Std. Dev.				± 20.8	± 43.0		± 6.5	±13.0
	(1400,150)	66	8.3	83.4	171.0	0.8	11.2	23.0
			10.5	104.5	214.0	1.8	21.5	44.0
			4.7	46.8	96.0	2.8	30.3	62.0
Mean				78.0	155.0		21.0	53.0
Std. Dev.				± 29.0	± 83.0		± 9.5	±13.0
	Site AS** (1100,150)	6	1.0	13.2	27.0	0.7	10.2	21.0
			4.4	44.4	91.0	0.8	11.2	23.0
			4.7	46.9	96.0	0.2	4.8	10.0
Mean				34.8	71.0		8.7	18.0
Std. Dev.				± 18.7	± 39.0		± 3.4	±7.0
	(1100,150)	23	2.6	28.8	59.0	0.9	12.2	25.0
			3.3	34.6	71.0	1.0	13.1	27.0
			2.9	31.2	64.0	0.6	9.3	19.0
Mean				31.5	65.0		11.5	24.0
Std. Dev.				± 18.7	± 6.0		± 1.9	± 4.0
	(1100,150)	53	4.6	45.9	94.0	1.2	15.1	31.0
			4.2	42.4	87.0	1.2	15.1	31.0
			4.3	43.4	89.0	1.2	15.1	31.0
Mean				43.9	90.0		15.1	31.0
Std. Dev.				1.8	4.0		± 0.0	± 0.0
	(1100,150)	83	6.0	61.0	125.0	0.3	8.3	13.0
			4.8	47.8	98.0	1.0	13.2	27.0
			3.9	40.0	82.0	1.2	4.8	10.0
Mean				49.6	102.0		8.8	18.0
Std. Dev.				±10.6	± 22.0		± 4.2	± 0.0

(continued)

* 33-mm vane shear diameter

** Subtidal zone at the Development Site

Table B'45 (Continued)

		UNDISTURBED			REMOLDED		
		Vane* Reading	Shear Stress		Vane* Reading	Shear Stress	
Location	cm	KPA	g/cm^2	lb/ft^2	KPA	g/cm^2	lb/ft^2
(1200,100)	6	8.6	86.4	177.0	0.6	9.2	19.0
	23	10.9	108.3	222.0	3.0	32.2	66.0
	53	6.2	62.9	129.0	1.4	17.57	36.0
(600,35)	6	14.0	139.1	285.0	0.2	4.8	10.0
		15.7	156.2	320.0	0.2	4.8	10.0
Mean			147.6	303.0	-	4.8	10.0
Std. Dev.			± 12.0	± 25.0		± 0.0	± 0.0
(600,35)	23	8.5	85.4	175.0	1.7	20.5	42.0
		10.0	100.0	205.0	0.7	10.2	21.0
Mean			92.7	190.0		15.3	32.0
Std. Dev.			± 10.3	± 21.0		± 7.2	±15.0
(600,35)	36	11.5	114.7	235.0	1.6	19.5	40.0
		13.2	131.3	269.0	4.0	40.5	83.0
(600,75)	6	4.0	40.5	83.0	0.3	5.8	12.0
		3.0	32.2	66.0	0.4	7.3	15.0
Mean			36.3	75.0		6.5	14.0
Std. Dev.			± 5.8	± 12.0		± 1.0	± 2.0
(600,75)	23	3.2	33.7	69.0	0.4	7.3	15.0
		5.3	53.2	109.0	1.0	13.2	27.0
			43.4	89.0		10.2	21.0
			± 13.7	± 28.0		± 4.7	± 8.0
(600,75)	53	5.2	52.0	107.0	1.0	13.2	27.0
		6.1	62.0	127.0	1.6	19.3	40.0
Mean			57.0	117.0		16.3	34.0
Std. Dev.			± 7.0	± 14.0		± 4.4	± 9.0
(600,75)	83	6.2	62.9	129.0	1.4	17.6	36.0
		6.9	68.8	141.0	2.3	26.4	54.0
Mean			65.8	135.0		22.0	45.0
Std. Dev.			± 4.7	± 8.0		± 6.2	±13.0
(600,100)	6	4.0	40.5	83.0	0.2	4.8	10.0
		2.8	30.5	62.0	0.1	3.9	8.0
Mean			35.5	73.0		4.3	9.0
Std. Dev.			± 7.0	± 15.0		± 0.63	± 1.0
(600,100)	23	4.2	42.5	87.0	0.4	7.3	15.0
		4.1	41.5	85.0	0.6	9.3	19.0
Mean			42.0	86.0		8.3	17.0
Std. Dev.			± 0.7	± 1.0		± 1.4	± 3.0
(600,100)	53	4.4	44.4	91.0	1.8	21.5	44.0
		5.7	57.6	118.0	1.9	22.4	46.0
Mean			51.0	105.0		21.95	45.0
Std. Dev.			± 9.3	± 19.0		± .63	± 1.0

(continued)

* 33-mm vane shear diameter

Table B'45 (Continued)

		Undisturbed			Remolded		
		Vane* Reading	Shear Stress		Vane* Reading	Shear Stress	
Location	cm	KPA	g/cm²	lb/ft²	KPA	g/cm²	lb/ft²
(600,100)	83	5.9	59.2	122.0	1.6	19.5	40.0
		4.3	43.4	89.0	0.8	11.2	23.0
Mean			51.3	111.0		15.35	32.0
Std. Dev.			± 11.1	± 19.0		± 5.8	±12.0
(600,225)	6	7.7	77.1	158.0	1.2	15.15	31.0
		2.0	23.4	48.0	0.2	4.8	10.0
		6.5	64.9	133.0	0.6	9.3	19.0
Mean			55.1	113.0		9.7	20.0
Std. Dev.			± 28.1	± 58.0		± 5.1	±11.0
(600,225)	23	4.3	43.4	89.0	1.0	13.2	27.0
		2.8	30.3	62.0	0.5	8.3	17.0
		3.6	37.1	76.0	1.3	16.1	33.0
Mean			36.9	76.0		12.5	26.0
Std. Dev.			± 6.5	± 14.0		± 3.9	± 8.0
(600,225)	53	5.8	58.6	120.0	1.0	13.2	27.0
		4.6	45.8	94.0	0.7	10.3	21.0
		4.3	43.4	89.0	1.4	17.6	36.0
Mean			49.2	101.0		13.7	28.0
Std. Dev.			± 8.1	± 17.0		± 3.6	± 8.0
(100,200)	6	1.4	17.6	36.0	0.0	0.0	0.0
		2.6	29.3	60.0	0.1	3.9	8.0
Mean			23.4	48.0		1.95	4.0
Std. Dev.			± 8.2	± 17.0		± 2.7	± 6.0
(100,200)	23	3.2	33.7	69.0	0.8	11.2	23.0
		2.3	26.4	54.0	0.5	8.3	17.0
Mean			30.0	62.0		9.7	20.0
Std. Dev.			± 5.1	± 11.0		± 2.0	± 4.0
(100,200)	53	5.9	59.6	122.0	1.2	15.1	31.0
		6.0	61.0	125.0	1.8	21.5	44.0
Mean			60.3	124.0		18.3	38.0
Std. Dev.			± 0.98	± 2.0		± 4.5	± 9.0
(100,200)	76	7.3	73.2	150.0	2.0	22.9	47.0
		6.0	61.0	125.0	1.8	21.5	44.0
Mean			67.1	138.0		22.2	46.0
Std. Dev.			± 8.6	± 18.0		± 0.9	± 2.0
Site AH** (100,400)	6	12.0	119.6	245	2.1	24.4	50.0
(100,400)	23	11.7	116.7	239.0	2.1	15.1	31.0
		14.0	138.6	284.0	2.1	15.1	31.0
Mean			126.6	262.0		15.1	31.0
Std. Dev.			15.4	32.0		0.0	0.0

(continued)

* 33-mm vane shear diameter

** High marsh at the Development Site

Table B'45 (Continued)

Location	cm	UNDISTURBED Vane* Reading KPA	UNDISTURBED Shear Stress g/cm²	UNDISTURBED Shear Stress lb/ft²	REMOLDED Vane* Reading KPA	REMOLDED Shear Stress g/cm²	REMOLDED Shear Stress lb/ft²
(100,400)	53	14.2	141.0	289.0	1.4	17.6	36.0
		13.6	134.7	276.0	1.9	22.5	46.0
Mean			137.8	283.0		25.0	41.0
Std. Dev.			± 4.4	± 9.0		± 3.4	± 7.0
(100,400)	83	11.0	109.8	225.0	2.4		56.0
		18.1	181.1	371.0	2.0	22.9	47.0
Mean			145.4	298.0			52.0
Std. Dev.			± 50.4	±103.0			± 6.0
(150,400)	6	8.8	88.5	181.0	1.3	16.1	33.0
		15.9	158.2	324.0	1.2	15.1	31.0
Mean			123.3	253.0		15.6	32.0
Std. Dev.			± 49.2	±101.0		± .7	± 1.0
(150,400)	23	11.2	111.8	229.0	1.7	20.5	42.0
		10.0	100.1	205.0	1.0	13.2	27.0
Mean			105.9	217.0		16.8	35.0
Std. Dev.			8.2	17.0		5.6	11.0
(150,400)	53	12.0	119.6	245.0	3.3	34.6	71.0
		13.0	131.3	269.0	1.5	18.3	38.0
Mean			125.4	257.0		26.5	55.0
Std. Dev.			± 8.2	± 17.0		±11.3	±23.0
(150,400)	83	11.3	112.7	231.0	2.2	25.4	52.0
		11.0	108.9	223.0	2.0	23.4	48.0
Mean			110.8	227.0		24.4	56.0
Std. Dev.			± 2.6	± 6.0		± 1.4	± 3.0
(150,400)	103	7.1	70.8	145.0	2.3	26.4	54.0
		9.2	93.2	191.0	2.5	28.8	59.0
Mean			82.0	168.0		27.6	56.0
Std. Dev.			± 15.8	± 33.0		± 1.6	± 3.0
Closest to Site AI** (200,400)	6	2.0	23.4	48.0	0.4	7.3	15.0
		2.7	29.8	61.0	0.4	7.3	15.0
Mean			26.6	55.0		7.3	15.0
Std. Dev.			± 4.5	± 9.0		± 0.0	± 0.0
(200,400)	23	4.8	47.8	98.0	0.6	9.3	19.0
		4.2	42.5	87.0	1.2	15.1	31.0
Mean			45.1	93.0		12.2	25.0
Std. Dev.			± 3.7	± 8.0		± 4.1	± 8.0
(200,400)	53	5.6	56.6	116.0	1.7	20.5	42.0
		6.8	68.8	141.0	2.0	23.4	48.0
Mean			62.7	129.0		21.9	45.0
Std. Dev.			± 8.6	± 18.0		± 2.05	± 4.0

(continued)

* 33-mm vane shear diameter

** Intertidal zone at Development Site was at 250,300 coordinates

Table B'45 (Continued)

		UNDISTURBED			REMOLDED		
		Vane* Reading	Shear Stress		Vane* Reading	Shear Stress	
Location	cm	KPA	g/cm²	lb/ft²	KPA	g/cm²	lb/ft²
(200,400)	83	7.0	69.8	143.0	1.5	16.1	33.0
		7.2	72.3	148.0	2.0	22.9	47.0
Mean			71.0	146.0		19.5	41.0
Std. Dev.			± 1.7	± 4.0		± 4.8	±11.0
(250,450)	6	8.2	82.5	169.0	0.1	3.9	8.0
		17.2	171.8	352.0	1.0	13.1	27.0
Mean			127.15	261.0		8.5	18.0
Std. Dev.			± 63.1	±129.0		± 6.5	±13.0
(250,450)	23	9.4	94.7	194.0	1.2	15.1	31.0
		8.0	80.0	164.0	1.6	19.5	40.0
Mean			87.3	179.0		17.3	37.0
Std. Dev.			± 10.0	± 21.0		± 3.11	± 6.0
(250,450)	53	11.7	116.7	239.0	3.6	37.1	76.0
		12.3	122.5	251.0	2.0	24.3	48.0
Mean			119.6	248.0		30.2	62.0
Std. Dev.			± 4.1	± 8.0		± 9.6	±20.0
(300,475)	6	20.1	200.6	411.0	0.8	11.2	23.0
		18.2	180.6	370.0	0.3	8.3	17.0
Mean			190.6	391.0		9.7	20.0
Std. Dev.			± 14.1	± 29.0		± 2.05	± 4.0
(300,475)	23	15.0	146.9	301.0	1.3	16.1	33.0
		10.0	100.0	205.0	2.0	23.4	48.0
Mean			123.4	253.0		19.7	41.0
Std. Dev.			± 33.1	± 68.0		± 5.16	±11.0
(300,475)	30	8.3	83.5	171.0	2.0	23.4	48.0
(300,475)	53	10.0	100.0	205.0	1.6	19.5	40.0
		6.7	67.3	138.0	0.7	10.3	21.0
Mean			83.6	172.0		14.9	31.0
Std. Dev.			± 23.1	± 17.0		± 6.5	±13.0
(1100,350)	6	3.0	32.2	66.0	0.5	8.3	17.0
		8.5	85.9	176.0	3.5	36.6	75.0
Mean			59.0	121.0		22.4	46.0
Std. Dev.			± 35.0	± 78.0		±20.0	±41.0
(1100,350)	23	3.0	32.2	66.0	0.5	8.3	17.0
		2.8	30.3	62.0	0.9	12.2	25.0
Mean			31.2	64.0		10.2	21.0
Std. Dev.			± 1.34	± 3.0		± 2.7	± 6.0
(1100,350)	53	4.6	45.9	94.0	1.5	18.5	38.0
		5.5	55.6	114.0	1.5	18.5	38.0
Mean			50.75	104.0		18.5	38.0
Std. Dev.				± 14.0			± 0.0
(1100,350)	83	6.8	68.8	141.0		16.1	33.0

(continued)

* 33-mm vane shear diameter

Table B'45 (Concluded)

Reference Marsh

Location	cm	UNDISTURBED Vane* Reading KPA	UNDISTURBED Shear Stress g/cm²	UNDISTURBED Shear Stress lb/ft²	REMOLDED Vane* Reading KPA	REMOLDED Shear Stress g/cm²	REMOLDED Shear Stress lb/ft²
Core Site RH**	6	11.5	114.2	234.0	3.0	32.2	66.0
		5.0	49.8	102.0	1.1	14.2	29.0
Mean			82.0	168.0		23.2	48.0
Std. Dev.			± 45.5	± 93.0		±12.7	±26.0
Core Site RH	23	11.0	108.9	223.0	0.7	10.2	21.0
		11.4	113.7	233.0	1.1	14.2	29.0
Mean			111.3	228.0		12.2	25.0
Std. Dev.			± 3.39	± 7.0		± 2.8	± 6.0
Core Site RH	53	12.7	126.4	259.0	0.9	12.2	25.0
		8.3	83.0	171.0	0.8	11.2	23.0
Mean			104.7	215.0		11.7	24.0
Std. Dev.			± 30.6	± 62.0		± 0.7	± 1.0
Core Site RI**	6	9.0	90.8	186.0	0.5	12.2	25.0
		0.5	8.3	17.0	0.1	12.2	25.0
Mean			49.55	102.0		12.2	25.0
Std. Dev.			± 58.3	±120.0		± 0.0	± 0.0
Core Site RI	23	8.1	81.0	166.0	1.6	19.5	40.0
		1.8	21.5	44.0	0.1	3.9	8.0
Mean			51.2	105.0		11.7	24.0
Std. Dev.			± 42.0	± 86.0		±11.0	±23.0
Core Site RI	53	14.0	139.0	284.0	1.9	22.6	46.0
		11.3	112.8	231.0	1.8	21.2	44.0
Mean			125.9	258.0		21.9	45.0
Std. Dev.			± 18.5	± 37.0		± .95	± 1.0
Core Site RI	83	12.3	122.5	251.0	1.5	18.6	38.0
		11.0	109.4	224.0	2.9	31.2	64.0
Mean			115.9	238.0		24.9	51.0
Std. Dev.			± 9.2	± 19.0		± 8.9	±18.0
Statistics for Each Depth	6	mean	65.77	134.7		14.6	30.0
		std. dev.	46.65	95.5		12.4	25.4
	23	mean	81.27	166.5		11.9	24.5
		std. dev.	43.2	86.8		6.5	13.7
	53	mean	115.3	236.2		16.8	34.5
		std. dev.	24.0	48.5		5.9	12
	83	mean	102.7	210.5		18.5	38.0
		std. dev.	16.2	33.27		8.95	18.3

* 33-mm vane shear diameter

** High marsh (RH) and intertidal marsh (RI) zones at the reference marsh. Data are not available for subtidal zone in January 1977

Table B'46

Data for 48-hr Tidal Study in August 1976

STATION*	TIME	TEMP (C)	PH	COND (MMHO/CM)	TURB (FTU)	SUSP SOL (MG/L)	DISS O2 (MG/L)	O2 SAT (%)
AP 1	0720	23.2	7.30	0.166	23.	38.	4.95	57.81
AP 2	0920	24.4	7.50	0.163	67.	96.	5.41	63.72
AP 3	0925	24.6	7.30	0.157	36.	38.	5.52	65.26
AP 4	1035	26.0	7.70	0.162	27.	36.	5.92	71.81
AP 5	1150	26.4	********	0.159	26.	90.	5.75	70.26
AP 6	1300	26.8	7.05	0.159	27.	38.	4.68	57.60
AP 7	1335	27.2	6.92	0.162	23.	41.	4.61	57.15
AP 8	1445	27.0	6.92	0.173	31.	55.	4.87	60.15
AP 9	1610	28.4	7.10	0.189	77.	226.	4.91	62.17
AP 10	1655	28.4	7.15	0.193	70.	129.	5.41	69.51
AP 11	1745	27.3	7.00	0.192	59.	191.	5.41	67.18
AP 12	1825	27.1	7.20	0.197	48.	62.	5.40	66.82
AP 13	1920	25.9	7.45	0.172	37.	60.	7.51	90.94
AP 14	2025	26.4	7.60	0.169	34.	55.	7.78	95.26
AP 15	2130	25.8	7.10	0.163	35.	32.	6.83	82.55
AP 16	2240	25.7	7.10	0.161	29.	46.	******	******
AP 17	2350	25.0	7.05	0.160	26.	43.	******	******
AP 18	0145	25.2	6.80	0.172	50.	66.	4.09	48.89
AP 19	0300	24.3	6.80	0.168	31.	30.	******	******
AP 20	0420	22.4	6.95	0.173	19.	91.	3.69	41.85
AP 21	0515	22.4	6.95	0.184	34.	266.	3.40	38.56
AP 22	0621	21.7	6.90	0.213	74.	457.	5.15	57.63
AP 23	0715	22.0	7.00	******	78.	280.	******	******
AP 24	0750	22.0	6.80	0.197	110.	699.	******	******
AP 25	0857	25.2	7.40	0.169	25.	99.	6.44	76.99
AP 26	1000	26.5	7.60	0.166	23.	73.	6.74	82.51
AP 27	1046	28.3	7.40	0.161	17.	37.	6.84	86.46
AP 28	1200	29.3	7.55	0.161	26.	*****	6.95	89.40
AP 29-1†	1251	29.0	7.60	0.166	14.	29.	7.51	96.10
AP 29-2	1345	28.1	7.60	******	14.	*****	6.17	77.72
AP 30	1445	29.6	6.95	0.177	22.	28.	5.34	67.86
AP 31	1550	28.5	6.95	0.192	33.	32.	5.85	74.21
AP 32	1700	28.7	6.95	0.199	84.	273.	8.45	7.57
AP 33	1745	27.9	6.90	0.203	73.	386.	5.11	64.14
AP 34	1806	27.6	6.85	0.213	110.	525.	******	******
AP 35	1900	25.3	6.90	0.215	67.	121.	4.69	57.20
AP 36	2130	26.4	7.40	0.172	32.	56.	6.94	84.80
AP 37	2230	26.3	7.10	0.169	24.	31.	6.26	76.35
AP 38	2345	25.7	6.95	0.172	21.	73.	******	******
AP 39	0130	25.2	7.00	0.176	27.	64.	5.33	63.72
AP 40	0215	25.3	6.85	0.180	52.	63.	4.18	50.06
AP 41	0305	25.2	6.75	0.168	33.	40.	3.05	36.46
AP 42	0400	25.2	6.85	0.173	22.	43.	3.13	37.42
AP 43	0610	23.3	6.90	0.194	86.	75.	4.39	50.65
AP 44	0630	23.0	6.90	0.203	80.	29.	4.24	48.64
AP 45	0750	22.7	6.98	0.201	65.	46.	4.91	56.01
AP 46	****	******	******	******	*****	*****	******	******
AP 47	****	******	******	******	*****	*****	******	******
AP 48	****	******	******	******	*****	*****	******	******

* Station

AP = Artificial Habitat Development Site pipe

** ****** = No data

† AP 29-1, AP 29-2 = Error during shift change

PARAMETERS

Temperature, pH, Conductivity, Turbidity, Suspended Solids, Dissolved Oxygen, and Percent Oxygen Saturation

Table B'47

Data for 48-hr Tidal Study in August 1976

STATION*	TIME	TEMP (C)	PH	COND (MMHO/CM)	TURB (FTU)	SUSP SOL (MG/L)	DISS O2 (MG/L)	O2 SAT (%)
AB 1	0700	24.2	7.35	0.201	21.	29.	4.73	55.51
AB 2	0810	24.8	7.60	0.165	20.	34.	5.15	61.11
AB 3	0915	24.6	********	0.206	20.	39.	5.50	65.97
AB 4	1015	26.8	7.50	0.158	18.	33.	6.08	74.83
AB 5	1130	26.8	******	0.159	19.	35.	6.63	81.60
AB 6	1215	27.3	7.70	0.158	22.	*****	6.25	77.61
AB 7	1320	27.2	7.05	0.158	22.	30.	4.96	61.49
AB 8	1420	28.2	6.92	0.167	30.	*****	******	******
AB 9	1555	******	******	******	*****	*****	******	******
AB 10	1645	******	******	******	*****	*****	******	******
AB 11	1730	******	******	******	*****	*****	******	******
AB 12	****	******	******	******	*****	*****	******	******
AB 13	1900	26.5	7.50	0.176	28.	26.	7.85	96.29
AB 14	2015	26.9	7.30	0.175	27.	26.	7.84	96.66
AB 15	2100	27.1	7.40	0.168	25.	*****	7.24	89.59
AB 16	2220	26.7	7.30	0.165	23.	39.	6.53	80.23
AB 17	2325	26.5	7.30	0.165	22.	34.	6.07	74.31
AB 18	0125	25.6	7.00	0.164	29.	46.	5.44	65.51
AB 19	0233	25.2	6.85	0.166	44.	81.	4.82	57.62
AB 20	0406	23.8	6.80	0.174	22.	58.	3.80	44.26
AB 21	0447	22.8	6.80	0.175	27.	69.	4.66	53.26
AB 22	0621	******	******	******	*****	*****	******	******
AB 23	0715	******	******	******	*****	*****	******	******
AB 24	0750	******	******	******	*****	*****	******	******
AB 25	0842	25.6	7.35	0.172	32.	68.	6.33	76.23
AB 26	0945	26.5	8.10	0.176	29.	*****	6.19	75.65
AB 27	1033	26.4	7.60	0.157	23.	60.	6.78	82.95
AB 28	1145	27.8	8.10	0.166	16.	22.	7.61	95.35
AB 29-1[†]	1235	28.3	7.40	0.166	16.	10.	7.79	98.47
AB 29-2	1325	28.3	7.40	0.165	16.	24.	6.72	84.94
AB 30	1430	28.5	6.90	0.178	25.	21.	5.24	66.47
AB 31	1530	29.0	6.95	0.193	25.	18.	5.98	76.52
AB 32	****	******	******	******	*****	*****	******	******
AB 33	****	******	******	******	*****	*****	******	******
AB 34	****	******	******	******	*****	*****	******	******
AB 35	****	******	******	******	*****	*****	******	******
AB 36	2100	26.7	7.30	0.170	14.	49.	7.06	86.74
AB 37	2200	26.9	7.50	0.178	20.	30.	6.60	81.38
AB 38	2330	26.3	7.30	0.165	15.	28.	6.30	76.84
AB 39	0100	25.3	7.25	0.166	18.	30.	5.68	68.03
AB 40	0150	25.2	7.15	0.168	22.	36.	5.37	64.20
AB 41	0245	25.8	7.00	0.167	28.	43.	4.79	57.89
AB 42	0335	25.4	6.75	0.169	24.	29.	3.94	47.27
AB 43	0550	******	******	******	*****	*****	******	******
AB 44	0620	******	******	******	*****	*****	******	******
AB 45	0720	******	******	******	*****	*****	******	******
AB 46	****	******	******	******	*****	*****	******	******
AB 47	****	******	******	******	*****	*****	******	******
AB 48	****	******	******	******	*****	*****	******	******

* Station

AB = Artificial Habitat Development Site breach

** ****** = No data

† AB 29-1, AB 29-2 = Error during shift change

PARAMETERS

Temperature, pH, Conductivity, Turbidity, Suspended Solids, Dissolved Oxygen, and Percent Oxygen Saturation

Table B'48

Data for 48-hr Tidal Study in August 1976

STATION*	TIME	TEMP (C)	PH	COND (MMHO/CM)	TURB (FTU)	SUSP SOL (MG/L)	DISS O2 (MG/L)	O2 SAT (%)
RL 1	0745	27.4	********	0.162	19.	*****	6.13	76.26
RL 2	0840	25.4	7.50	0.163	20.	24.	6.29	75.47
RL 3	0945	25.8	******	0.162	18.	19.	7.60	91.86
RL 4	1110	26.4	******	0.162	17.	7.	7.73	94.45
RL 5	1145	26.8	7.80	0.171	15.	9.	5.10	62.77
RL 6	1245	27.6	7.80	0.165	15.	19.	8.34	4.13
RL 7	1345	29.2	7.81	0.164	15.	12.	8.01	1.07
RL 8	1445	27.0	7.10	0.159	12.	13.	8.32	2.77
RL 9	1545	27.7	7.00	0.161	12.	32.	8.65	8.19
RL 10	1645	27.5	7.10	0.161	16.	19.	9.04	12.66
RL 11	1745	27.4	7.00	0.172	17.	25.	8.66	7.74
RL 12	1945	27.3	7.35	0.153	17.	27.	9.82	9.93
RL 13	1945	27.0	7.45	0.162	21.	16.	******	******
RL 14	2045	26.9	7.55	0.167	12.	27.	7.38	90.99
RL 15	2145	26.9	7.45	0.164	20.	22.	7.29	89.88
RL 16	2245	26.8	7.55	0.165	13.	32.	6.90	84.92
RL 17	2345	26.8	7.60	0.164	18.	2.	6.51	90.12
RL 18	0045	26.9	7.40	0.165	17.	23.	6.86	84.58
RL 19	0145	26.3	7.10	0.167	17.	19.	6.40	78.06
RL 20	0245	26.0	7.00	0.169	12.	22.	5.43	65.87
RL 21	0345	25.3	6.80	0.164	16.	*****	******	******
RL 22	0445	25.2	6.70	0.161	15.	22.	4.36	52.12
RL 23	0545	******	6.85	0.163	17.	24.	5.89	******
RL 24	0645	25.1	******	******	*****	21.	4.88	58.23
RL 25	0745	25.0	6.85	0.153	17.	4.	******	******
RL 26	0845	25.5	******	0.153	*****	*****	******	******
RL 27	0945	25.8	7.20	0.166	18.	*****	******	******
RL 28	1045	26.3	7.40	0.166	15.	*****	******	******
RL 29	1145	26.3	7.70	0.165	17.	93.	8.37	2.89
RL 30	1245	28.0	7.95	0.167	15.	19.	8.50	6.88
RL 31	1345	29.6	8.25	0.163	12.	16.	6.05	78.23
RL 32	1445	28.3	8.15	0.162	10.	66.	8.81	11.36
RL 33	1545	28.0	7.55	0.166	13.	19.	******	******
RL 34	1645	28.4	7.35	0.169	16.	29.	9.50	20.30
RL 35	1745	27.9	7.35	0.162	16.	33.	10.07	26.39
RL 36	1845	27.8	7.20	0.161	16.	31.	8.74	9.51
RL 37	1945	27.4	7.30	0.153	20.	42.	8.73	8.61
RL 38	2045	26.9	7.80	0.162	21.	36.	7.50	92.47
RL 39	2145	27.2	7.95	0.166	18.	35.	8.04	99.67
RL 40	2245	26.9	7.65	0.168	18.	29.	7.34	90.50
RL 41	2345	26.8	7.55	0.176	17.	31.	6.97	85.78
RL 42	0045	26.7	7.50	0.167	18.	49.	6.91	84.89
RL 43	0145	26.5	7.25	0.162	17.	24.	6.95	85.08
RL 44	0245	26.3	7.10	0.167	17.	24.	6.32	77.09
RL 45	0345	26.0	6.90	0.187	13.	24.	6.03	73.15
RL 46	0445	25.8	6.70	0.163	12.	20.	4.33	52.34
RL 47	0545	25.6	6.75	0.166	14.	23.	4.49	54.07
RL 48	0645	25.8	6.75	0.163	14.	23.	4.99	60.31
RL 49	0745	25.8	6.95	0.156	14.	35.	4.92	59.47

* Station
RL = Reference marsh large channel

** ****** = No data.

PARAMETERS

Temperature, pH, Conductivity, Suspended Solids, Dissolved Oxygen, and Percent Oxygen Saturation

Table B'49

Data for 48-hr Tidal Study in August 1976

STATION*	TIME	TEMP (C)	PH	COND (MMHO/CM)	TURB (FTU)	SUSP SOL (MG/L)	DISS O2 (MG/L)	O2 SAT (%)
RS 1	0755	25.4	7.55	0.162	19.	********	6.21	74.51
RS 2	0855	25.4	******	0.172	22.	17.	6.68	80.15
RS 3	0955	25.8	******	0.163	16.	22.	7.21	87.15
RS 4	1055	26.0	******	0.166	17.	23.	7.17	86.98
RS 5	1155	26.0	7.40	0.163	17.	14.	4.99	60.53
RS 6	1255	26.5	7.30	0.168	12.	16.	6.73	82.38
RS 7	1355	27.6	7.25	0.163	17.	18.	7.58	94.64
RS 8	1455	27.1	6.80	0.161	16.	10.	7.93	98.13
RS 9	1555	27.3	6.90	0.166	14.	9.	6.78	84.20
RS 10	1650	27.5	6.90	0.165	14.	15.	7.62	94.97
RS 11	1810	27.4	7.30	0.159	17.	20.	9.70	8.23
RS 12	1850	27.3	7.40	0.164	23.	22.	8.17	1.46
RS 13	1950	26.9	7.63	0.202	19.	19.	7.78	95.93
RS 14	2050	27.0	7.65	0.173	11.	33.	7.48	92.39
RS 15	2150	26.9	7.60	0.158	18.	27.	6.99	86.19
RS 16	2250	26.8	7.45	0.165	21.	34.	7.00	86.15
RS 17	2350	26.6	7.30	0.168	16.	2.	6.39	78.36
RS 18	0050	26.9	7.25	0.169	18.	22.	5.84	72.01
RS 19	0155	26.1	7.10	0.166	17.	21.	9.57	16.30
RS 20	0255	26.0	6.80	0.167	18.	*****	5.20	63.80
RS 21	0345	26.0	7.15	0.164	22.	*****	4.26	51.68
RS 22	0445	25.6	******	0.175	*****	25.	******	******
RS 23	0545	25.6	6.70	0.174	18.	19.	3.02	36.37
RS 24	0645	25.6	6.90	0.155	15.	18.	5.56	66.96
RS 25	0745	25.2	6.90	0.156	16.	*****	******	******
RS 26	0845	25.1	7.15	0.169	17.	*****	******	******
RS 27	0945	25.9	7.30	0.173	18.	*****	******	******
RS 28	1045	26.5	7.60	0.166	19.	*****	******	******
RS 29	1145	27.1	7.60	0.167	13.	17.	8.29	2.58
RS 30	1245	27.2	7.50	0.165	15.	28.	9.58	6.36
RS 31	1400	28.2	8.55	0.167	14.	33.	8.43	6.37
RS 32	1450	27.8	7.30	0.163	14.	25.	8.50	6.50
RS 33	1550	28.1	7.10	0.163	12.	21.	8.39	5.68
RS 34	1730	29.1	7.25	0.165	12.	21.	8.15	2.66
RS 35	****	******	******	******	*****	*****	******	******
RS 36	****	******	******	******	*****	*****	******	******
RS 37	2000	26.7	7.95	0.166	20.	30.	8.00	98.28
RS 38	2050	26.1	7.85	0.162	20.	41.	7.84	95.28
RS 39	2150	26.7	8.15	0.167	19.	20.	7.94	97.55
RS 40	2300	26.9	7.80	0.168	22.	38.	6.85	84.46
RS 41	2350	26.7	7.55	0.168	20.	37.	6.64	81.58
RS 42	0050	26.7	7.50	0.169	19.	30.	7.09	87.10
RS 43	0155	26.4	7.10	0.169	17.	25.	6.84	83.58
RS 44	0300	26.2	******	0.167	15.	31.	5.87	71.47
RS 45	0355	25.8	******	0.166	*****	25.	4.81	58.14
RS 46	0455	25.4	6.65	0.166	21.	30.	4.08	48.95
RS 47	0555	25.1	6.65	0.165	17.	30.	3.80	45.34
RS 48	0655	24.8	6.60	0.166	15.	20.	3.26	38.68
RS 49	0755	******	7.00	0.157	15.	18.	6.24	******

* Station
RS = Reference marsh small channel

** ****** = No data

PARAMETERS

Temperature, pH, Conductivity, Suspended Solids, Dissolved Oxygen, and Percent Oxygen Saturation

Table B'50

Data for 48-hr Tidal Study in August 1976

STATION*	TIME	ALK (MEQ/L)	CHL (UG/L)	PHAE (UG/L)	FOFA	VOL C (MG/L)	TOT C (MG/L)
AP 1	0720	7.06	7.96	1.92	1.81	1.6	15.8
AP 2	0820	7.09	14.10	5.76	1.71	1.5	10.2
AP 3	0925	6.21	8.23	4.80	1.63	1.8	7.8
AP 4	1035	********	9.47	4.25	1.69	3.4	10.8
AP 5	1150	5.65	10.80	2.88	1.79	3.5	19.8
AP 6	1300	1.55	10.80	2.33	1.82	3.4	9.4
AP 7	1335	6.37	******	******	******	4.6	5.6
AP 8	1445	3.56	9.20	3.02	1.75	3.3	11.5
AP 9	1610	7.03	7.68	3.16	1.71	3.0	24.8
AP 10	1655	3.72	10.70	7.27	1.62	3.5	5.6
AP 11	1745	2.74	4.24	4.12	1.51	2.3	5.1
AP 12	1825	6.56	5.35	1.92	1.74	1.7	6.7
AP 13	1920	2.87	11.10	6.72	1.62	1.2	13.2
AP 14	2025	4.79	11.40	5.35	1.68	1.1	3.4
AP 15	2130	5.64	10.30	2.74	1.79	0.7	3.6
AP 16	2240	2.33	7.00	2.74	1.72	2.7	11.3
AP 17	2350	4.57	6.86	4.12	1.62	5.1	10.2
AP 18	0145	5.17	8.92	5.90	1.60	5.6	13.0
AP 19	0300	6.62	7.41	4.25	1.64	10.7	17.1
AP 20	0420	1.96	7.55	4.12	1.65	******	******
AP 21	0515	2.43	8.78	7.27	1.55	9.1	12.5
AP 22	0621	5.55	8.23	11.20	1.42	******	******
AP 23	0715	7.31	10.70	5.90	1.54	10.2	14.5
AP 24	0750	2.74	19.10	17.70	1.52	9.0	14.0
AP 25	0857	2.40	11.90	4.80	1.71	4.6	7.3
AP 26	1000	5.80	13.40	5.35	1.72	******	******
AP 27	1046	2.81	9.10	3.70	1.69	******	******
AP 28	1200	4.82	8.92	0.96	1.90	7.1	11.3
AP 29-1	1251	5.58	8.64	3.84	1.69	******	******
AP 29-2	1345	5.58	11.70	2.74	1.81	******	******
AP 30	1445	1.74	15.60	2.88	1.84	******	******
AP 31	1550	2.60	13.20	5.00	1.76	5.9	9.3
AP 32	1700	3.18	8.78	7.60	1.53	0.9	7.7
AP 33	1745	6.71	6.72	8.78	1.43	0.1	4.2
AP 34	1806	6.08	18.10	13.70	1.56	0.8	12.9
AP 35	1900	6.00	4.39	2.36	1.65	0.7	9.1
AP 36	2130	5.42	12.60	3.84	1.76	1.0	6.3
AP 37	2230	5.33	17.60	1.92	1.61	2.7	10.8
AP 38	2345	2.09	11.10	4.67	1.70	1.0	12.8
AP 39	0130	1.86	13.00	10.30	1.52	0.9	9.9
AP 40	0215	5.07	10.40	3.84	1.73	0.4	6.2
AP 41	0305	2.55	7.82	3.84	1.67	1.0	12.2
AP 42	0400	3.00	6.31	2.47	1.72	2.1	10.6
AP 43	0610	2.96	6.45	2.47	1.72	1.9	8.1
AP 44	0630	2.87	7.27	1.65	1.82	1.9	14.9
AP 45	0750	3.81	6.45	1.92	1.77	******	******
AP 46	****	******	******	******	******	******	******
AP 47	****	******	******	******	******	******	******
AP 48	****	******	******	******	******	******	******

* Station
AP = Artificial Habitat Development Site pipe

** ****** = No data

+ AP 29-1, AP 29-2 = Error during shift change

PARAMETERS

Alkalinity, Chlorophyll, Phaeophytin, Fo/Fa Ratio, Volatile Dissolved Organic Carbon, and Total Dissolved Organic Carbon

Table B'51

Data for 48-hr Tidal Study in August 1976

STATION*	TIME	ALK (MEQ/L)	CHL (UG/L)	PHAE (UG/L)	FOFA	VOL C (MG/L)	TOT C (MG/L)
AB 1	0700	5.99	9.74**	3.70	1.72	2.3	10.2
AB 2	0810	7.22	******	******	******	2.6	15.5
AB 3	0915	6.14	10.30	2.20	1.82	1.4	33.1
AB 4	1015	3.72	9.88	3.84	1.72	1.2	9.8
AB 5	1130	5.58	12.50	2.74	1.82	1.4	13.5
AB 6	1215	4.10	14.30	1.92	1.88	3.0	7.9
AB 7	1320	6.81	9.26	3.22	1.74	2.2	10.1
AB 8	1420	1.80	12.50	1.65	1.88	1.9	12.1
AB 9	1555	******	******	******	******	******	******
AB 10	1645	******	******	******	******	******	******
AB 11	1730	******	******	******	******	******	******
AB 12	****	******	******	******	******	******	******
AB 13	1900	1.76	12.10	4.53	1.73	0.4	5.8
AB 14	2015	1.67	13.60	5.63	1.71	1.0	9.4
AB 15	2100	1.99	7.41	6.31	1.64	2.0	5.4
AB 16	2220	1.74	12.49	5.76	1.64	1.2	3.3
AB 17	2325	1.52	9.47	5.76	1.62	0.0	3.5
AB 18	0125	1.74	9.20	3.15	1.74	4.9	9.0
AB 19	0233	5.77	9.33	5.22	1.64	1.1	8.1
AB 20	0406	1.64	10.80	2.33	1.82	1.2	4.7
AB 21	0447	5.70	8.10	2.33	1.78	0.4	4.7
AB 22	0621	******	******	******	******	******	******
AB 23	0715	******	******	******	******	******	******
AB 24	0750	5.83	******	******	******	******	******
AB 25	0842	1.70	15.50	3.29	1.82	0.3	6.2
AB 26	0945	2.18	14.80	3.43	1.81	******	******
AB 27	1033	6.74	8.37	2.61	1.72	******	******
AB 28	1145	1.64	17.30	2.74	1.86	******	******
AB 29-1	1235	1.67	8.23	3.84	1.68	******	******
AB 29-2	1325	1.67	9.06	1.37	1.87	******	******
AB 30	1430	1.75	10.70	3.29	1.76	1.7	6.7
AB 31	1530	5.26	9.61	2.74	1.78	3.7	8.9
AB 32	****	******	******	******	******	******	******
AB 33	****	******	******	******	******	******	******
AB 34	****	******	******	******	******	******	******
AB 35	****	******	******	******	******	******	******
AB 36	2100	1.67	11.70	5.08	1.70	1.2	16.6
AB 37	2200	3.97	13.20	4.53	1.74	0.9	8.5
AB 38	2330	3.88	8.10	4.94	1.62	2.0	8.0
AB 39	0100	6.05	9.33	3.98	1.70	3.3	6.5
AB 40	0150	5.07	8.92	4.12	1.68	1.6	4.9
AB 41	0245	2.24	10.20	3.02	1.77	0.8	4.8
AB 42	0335	5.64	8.23	3.43	1.71	1.4	4.5
AB 43	0550	******	******	******	******	******	******
AB 44	0620	******	******	******	******	******	******
AB 45	0700	******	******	******	******	******	******
AB 46	****	******	******	******	******	******	******
AB 47	****	******	******	******	******	******	******
AB 48	****	******	******	******	******	******	******

* Station
AB = Artificial Habitat Development Site breach

** ****** = No data

+ AB 29-1, AB 29-2 = Error during shift change

PARAMETERS

Alkalinity, Chlorophyll, Phaeophytin, Fo/Fa Ratio, Volatile Dissolved Organic Carbon, and Total Dissolved Organic Carbon

Table B'52

Data for 48-hr Tidal Study in August 1976

STATION*	TIME	ALK (MEQ/L)	CHL (UG/L)	PHAE (UG/L)	FOFA	VOL C (MG/L)	TOT C (MG/L)
RL 1	0745	1.83	9.61	4.25	1.71	0.7	13.1
RL 2	0840	6.41	18.90	2.47	1.88	2.5	26.2
RL 3	0945	7.09	7.14	2.47	1.74	0.4	7.9
RL 4	1110	3.91	11.70	3.43	1.77	0.4	10.7
RL 5	1145	5.84	12.40	1.65	1.88	0.8	11.2
RL 6	1245	2.64	********	******	******	0.4	6.7
RL 7	1345	6.56	7.93	2.57	1.76	0.8	5.0
RL 8	1445	2.24	7.68	******	2.04	******	******
RL 9	1545	1.55	11.40	3.43	1.77	0.6	10.1
RL 10	1645	1.90	14.30	7.14	1.67	0.9	8.4
RL 11	1745	5.01	23.20	7.14	1.76	1.0	21.4
RL 12	1845	1.64	21.70	6.04	1.78	******	******
RL 13	1945	2.11	19.80	7.41	1.67	0.0	3.0
RL 14	2045	5.11	8.70	7.96	1.56	1.0	9.3
RL 15	2145	5.55	17.20	5.49	1.76	0.8	3.6
RL 16	2245	1.48	16.30	9.20	1.64	0.6	6.3
RL 17	2345	7.00	12.00	5.49	1.68	0.5	4.4
RL 18	0045	4.70	10.30	4.39	1.70	2.0	40.0
RL 19	0145	6.21	20.00	******	2.04	******	******
RL 20	0245	4.85	13.00	4.67	1.74	******	******
RL 21	0345	5.26	******	******	******	0.6	5.9
RL 22	0445	4.51	8.10	2.20	1.79	1.9	7.0
RL 23	0545	6.10	******	******	******	0.8	3.6
RL 24	0645	******	******	******	2.35	0.8	2.7
RL 25	0745	1.96	18.90	6.04	1.76	0.6	5.5
RL 26	0845	******	14.10	5.90	1.70	0.2	2.1
RL 27	0945	1.75	******	******	******	2.3	5.1
RL 28	1045	5.20	15.90	7.00	1.70	******	******
RL 29	1145	1.94	4.93	2.92	1.63	0.7	2.8
RL 30	1245	1.52	10.70	6.04	1.68	0.6	6.2
RL 31	1345	5.23	12.20	4.53	1.73	******	******
RL 32	1445	5.04	11.80	3.98	1.69	1.1	8.3
RL 33	1545	1.52	18.10	7.60	1.70	0.4	8.2
RL 34	1645	1.52	13.90	5.35	1.72	1.5	8.4
RL 35	1745	5.26	15.20	6.04	1.72	0.7	8.1
RL 36	1845	4.26	12.60	5.22	1.71	2.0	8.8
RL 37	1945	2.02	16.30	6.18	1.73	0.1	6.5
RL 38	2045	5.07	18.20	6.86	1.73	0.5	5.2
RL 39	2145	1.48	19.20	8.92	1.73	1.4	8.3
RL 40	2245	3.56	24.20	9.61	1.75	0.8	6.5
RL 41	2345	4.63	13.40	8.10	1.62	0.4	2.6
RL 42	0045	3.53	12.40	3.98	1.76	1.6	7.8
RL 43	0145	5.20	13.90	5.35	1.72	4.0	10.6
RL 44	0245	2.24	12.60	7.55	1.63	6.0	14.1
RL 45	0345	4.10	10.00	6.18	1.62	0.7	4.7
RL 46	0445	1.33	12.10	6.04	1.67	6.7	11.4
RL 47	0545	5.70	11.70	5.49	1.68	4.5	16.1
RL 48	0645	3.94	13.40	6.04	1.69	1.6	14.0
RL 49	0745	4.41	23.20	4.39	1.84	1.3	4.4

* Station
RL = Reference marsh large channel

** ****** = No data

PARAMETERS

Alkalinity, Chlorophyll, Phaeophytin, Fo/Fa Ratio, Volatile Dissolved Organic Carbon, and Total Dissolved Organic Carbon

Table B'53

Data for 48-hr Tidal Study in August 1976

STATION*	TIME	ALK (MEG/L)	CHL (UG/L)	PHAE (UG/L)	FOFA	VOL C (MG/L)	TOT C (MG/L)
RS 1	0755	7.25	13.30	1.92	1.67	1.5	24.7
RS 2	0855	1.67	11.20	5.00	1.75	0.7	7.4
RS 3	0955	3.59	13.90	3.98	1.78	0.8	5.8
RS 4	1055	6.84	15.00	0.14	2.00	0.7	8.2
RS 5	1155	4.90	13.90	5.49	1.72	********	******
RS 6	1255	1.00	12.20	3.16	1.80	0.7	9.3
RS 7	1355	5.86	6.45	3.16	1.67	0.0	4.4
RS 8	1455	6.81	8.70	3.43	1.72	******	******
RS 9	1555	2.24	8.10	6.86	1.54	1.4	6.7
RS 10	1650	2.65	14.40	1.37	1.91	0.5	5.5
RS 11	1810	1.77	17.30	4.60	1.79	1.3	9.3
RS 12	1850	5.42	21.40	12.50	1.63	0.6	6.0
RS 13	1950	5.64	14.30	9.10	1.64	1.6	3.7
RS 14	2050	1.61	9.47	1.92	1.83	0.6	1.5
RS 15	2150	6.43	14.00	6.45	1.68	2.0	3.8
RS 16	2250	5.73	15.80	8.51	1.65	2.2	9.0
RS 17	2350	2.45	9.47	3.02	1.76	0.8	5.9
RS 18	0050	1.99	13.70	4.39	1.76	1.2	9.4
RS 19	0155	2.46	29.20	10.80	1.68	******	******
RS 20	0255	6.27	13.00	4.67	1.74	2.6	4.9
RS 21	0345	6.37	13.40	5.35	1.72	0.9	5.3
RS 22	0445	******	9.87	5.70	1.65	0.7	3.2
RS 23	0545	5.50	14.40	5.08	1.74	1.8	5.6
RS 24	0645	1.92	17.60	8.37	1.68	0.4	4.4
RS 25	0745	1.93	32.40	******	2.19	0.4	7.1
RS 26	0845	1.89	9.30	3.13	1.72	2.0	5.0
RS 27	0945	1.86	14.30	5.08	1.74	0.2	3.9
RS 28	1045	5.23	7.27	0.55	1.93	******	******
RS 29	1145	5.33	******	******	******	2.9	11.0
RS 30	1245	4.98	7.25	3.46	1.73	******	******
RS 31	1400	2.05	12.60	7.96	1.98	******	******
RS 32	1450	4.63	7.92	2.57	1.72	1.5	11.3
RS 33	1550	2.46	15.60	5.08	1.76	3.7	27.6
RS 34	1730	1.67	11.90	4.39	1.73	1.0	3.9
RS 35	****	******	******	******	******	******	******
RS 36	****	******	******	******	******	******	******
RS 37	2000	2.02	17.60	6.59	1.73	1.8	10.9
RS 38	2050	5.64	15.60	4.94	1.76	0.5	11.3
RS 39	2150	1.52	20.30	0.41	1.98	0.6	16.4
RS 40	2300	4.76	18.10	5.08	1.79	3.5	9.9
RS 41	2350	5.70	9.88	4.80	1.67	0.5	5.7
RS 42	0050	5.20	11.50	5.90	1.66	1.0	13.0
RS 43	0155	4.19	11.90	5.76	1.67	3.9	12.7
RS 44	0300	1.74	10.00	5.63	1.64	2.9	9.7
RS 45	0355	******	13.40	3.70	1.79	4.5	9.5
RS 46	0455	4.67	11.00	7.96	1.53	1.9	11.2
RS 47	0555	5.45	7.82	4.80	1.58	3.6	15.5
RS 48	0655	4.76	12.90	2.47	1.84	2.9	9.0
RS 49	0755	2.14	20.40	8.10	1.72	2.6	6.2

* Station
RS = Reference marsh small channel

** ****** = No data

PARAMETERS

Alkalinity, Chlorophyll, Phaeophytin, Fo/Fa Ratio, Volatile Dissolved Organic Carbon, and Total Dissolved Organic Carbon

Table B'54

Data for 48-hr Tidal Study in August 1976

STATION*		HG (UG/L)	NH4A† (MG/L)	NH4B†† (MG/L)	NO2+NO3 (MG/L)	PO4 (MG/L)	TDN (MG/L)	TDP (MG/L)	TKN (MG/L)	TP (MG/L)
APA	1	0.403	0.392	0.55	0.55	0.066	1.45	0.103	6.63	0.168
APA	2	0.631	0.224	0.53	0.68	0.062	1.19	0.084	6.71	0.173
APA	3	0.571	0.336	0.39	0.65	0.068	4.12	0.092	4.67	0.228
APA	4	0.438	0.336	0.53	0.50	0.081	4.25	0.099	4.34	0.224
APA	5	********	0.416	0.37	0.22	0.146	2.02	0.196	2.05	0.446
APA	6	0.288	0.456	0.52	0.42	0.111	1.29	0.176	6.60	0.304
APA	7	0.398	0.360	0.49	0.76	0.071	3.01	0.101	******	******
APA	8	0.826	0.352	0.42	0.73	0.047	1.98	0.054	5.01	0.203
APA	9	0.391	0.328	0.63	0.56	0.066	4.45	0.071	6.86	0.151
APA	10	0.416	0.496	1.16	0.23	0.056	2.06	0.068	6.81	0.421
APA	11	1.851	0.416	0.47	0.46	0.049	7.13	0.077	9.24	0.379
APA	12	0.486	0.336	0.45	0.67	0.049	4.41	0.053	7.66	0.171
APA	13	1.780	0.416	0.34	0.65	0.045	1.62	0.054	8.50	0.119
APA	14	0.422	0.478	0.64	0.54	0.056	4.91	0.094	9.41	0.124
APA	15	0.483	0.514	0.79	0.27	0.038	1.69	0.055	6.23	0.292
APA	16	0.932	0.561	0.74	0.17	0.109	4.75	0.146	4.35	0.312
APA	17	0.759	0.526	0.91	0.48	0.066	2.80	0.094	******	******
APA	18	0.836	0.894	0.69	0.65	0.056	1.53	0.079	3.48	0.296
APA	19	0.234	0.496	0.68	1.05	0.059	4.29	0.063	3.04	0.234
APA	20	0.741	0.792	0.54	0.54	0.074	1.86	0.101	2.56	0.264
APA	21	******	******	******	******	******	******	******	******	******
APB	1	0.384	******	0.52	0.39	0.025	1.89	0.067	******	******
APB	2	0.776	******	0.41	0.72	0.049	1.32	0.058	******	******
APB	3	0.367	******	0.36	0.73	0.052	4.86	0.053	******	******
APB	4	0.403	******	0.67	0.51	0.107	5.52	0.111	******	******
APB	5	0.554	******	0.31	0.20	0.141	3.13	0.175	******	******
APB	6	0.309	******	0.41	0.48	0.130	0.82	0.147	******	******
APB	7	0.418	******	0.64	0.74	0.143	4.00	0.151	******	******
APB	8	0.850	******	0.47	0.79	0.109	3.54	0.131	******	******
APB	9	0.540	******	0.78	0.58	0.117	5.44	0.142	******	******
APB	10	0.454	******	1.03	0.29	0.101	3.71	0.135	******	******
APB	11	1.324	******	0.32	0.44	0.121	6.34	0.143	******	******
APB	12	0.506	******	0.64	0.74	0.067	4.16	0.104	******	******
APB	13	******	******	0.32	0.60	0.072	3.09	0.103	******	******
APB	14	0.438	******	0.71	0.55	0.125	4.04	0.132	******	******
APB	15	0.592	******	0.79	0.27	0.061	2.79	0.082	******	******
APB	16	0.900	******	0.69	0.17	0.087	4.49	0.106	******	******
APB	17	0.759	******	0.84	0.56	0.069	2.35	0.091	******	******
APB	18	0.869	******	0.58	0.55	0.049	1.28	0.076	******	******
APB	19	0.316	******	0.74	0.70	0.072	5.27	0.091	******	******
APB	20	0.607	******	0.51	0.50	0.106	3.00	0.134	******	******
APB	21	******	******	******	******	******	******	******	******	******

* Station
APA = Artificial Habitat Development Site pipe (alpha sample), and APB = Artificial Habitat Development Site pipe (beta sample)

** ****** = No data

† NH_4 A = Dissolved Ammonium, H_2SO_4 storage

†† NH_4 B = Dissolved Ammonium, $HClO_4$ storage

PARAMETERS

Dissolved Mercury, Dissolved Ammonium, Dissolved Ammonium, Dissolved Nitrate plus Nitrite, Dissolved Orthophosphate, Total Dissolved Nitrogen, Total Dissolved Phosphorus, Total Kjeldahl Nitrogen (unfiltered sample), and Total Phosphorus (unfiltered sample)

Table B'55

Data for 48-hr Tidal Study in August 1976

STATION*		HG (UG/L)	NH4A† (MG/L)	NH4B†† (MG/L)	NO2+NO3 (MG/L)	PO4 (MG/L)	TDN (MG/L)	TDP (MG/L)	TKN (MG/L)	TP (MG/L)
ABA	1	********	******	******	******	******	******	******	******	******
ABA	2	0.383	0.431	0.51	******	******	1.28	0.053	2.93	0.184
ABA	3	0.524	0.292	0.49	******	******	2.02	0.066	3.14	0.238
ABA	4	0.631	0.571	0.38	******	******	4.82	0.072	7.45	0.212
ABA	5	******	******	******	******	******	******	******	******	******
ABA	6	******	******	******	******	******	******	******	******	******
ABA	7	0.431	0.550	0.51	******	******	4.03	0.063	6.72	0.312
ABA	8	******	0.544	0.33	******	******	2.68	0.072	3.69	0.261
ABA	9	0.422	0.558	0.51	******	******	2.35	0.076	3.44	0.224
ABA	10	******	******	******	******	******	******	******	******	******
ABA	11	******	******	******	******	******	******	******	******	******
ABA	12	0.643	0.670	0.66	******	******	3.13	0.099	3.99	0.191
ABA	13	0.841	0.614	0.73	******	******	3.42	0.076	3.48	0.152
ABA	14	0.422	0.544	0.72	******	******	4.29	0.058	5.91	0.137
ABA	15	******	******	******	******	******	******	******	******	******
ABA	16	******	******	******	******	******	******	******	******	******
ABA	17	0.506	0.398	0.61	******	******	3.54	0.075	3.40	0.175
ABA	18	0.309	0.503	0.73	******	******	3.46	0.084	5.81	0.173
ABA	19	0.383	0.515	0.62	******	******	4.07	0.087	4.28	0.281
ABA	20	******	******	******	******	******	******	******	******	******
ABA	21	******	******	******	******	******	******	******	3.78	0.248
ABB	1	******	******	******	******	******	******	******	******	******
ABB	2	0.365	******	0.48	0.50	0.033	4.45	0.078	******	******
ABB	3	0.490	******	0.54	0.76	0.029	4.50	0.072	******	******
ABB	4	0.471	******	0.49	0.75	0.091	4.82	0.108	******	******
ABB	5	******	******	******	******	******	******	******	******	******
ABB	6	******	******	******	******	******	******	******	******	******
ABB	7	0.478	******	0.57	0.77	0.038	4.08	0.081	******	******
ABB	8	0.723	******	0.39	0.66	0.044	3.59	0.077	******	******
ABB	9	0.383	******	0.57	0.57	0.078	3.31	0.103	******	******
ABB	10	******	******	******	******	******	******	******	******	******
ABB	11	******	******	******	******	******	******	******	******	******
ABB	12	0.501	******	0.40	0.70	0.053	3.42	0.086	******	******
ABB	13	0.669	******	0.53	0.73	0.024	4.29	0.072	******	******
ABB	14	0.438	******	0.81	0.56	0.080	4.16	0.104	******	******
ABB	15	******	******	******	******	******	******	******	******	******
ABB	16	******	******	******	******	******	******	******	******	******
ABB	17	0.580	******	0.64	0.69	0.044	3.46	0.083	******	******
ABB	18	0.304	******	0.99	0.67	0.072	4.04	0.086	******	******
ABB	19	1.636	******	0.57	0.91	0.061	4.41	0.092	******	******
ABB	20	******	******	******	******	******	******	******	******	******
ABB	21	******	******	******	******	******	******	******	******	******

* Station
ABA = Artificial Habitat Development Site breach (alpha sample), and ABB = Artificial Habitat Development Site breach (beta sample)

** ****** = No data

† NH_4 A = Dissolved Ammonium, H_2SO_4 storage

†† NH_4 B = Dissolved Ammonium, $HClO_4$ storage

PARAMETERS

Dissolved Mercury, Dissolved Ammonium, Dissolved Ammonium, Dissolved Nitrate plus Nitrite, Dissolved Orthophosphate, Total Dissolved Nitrogen, Total Dissolved Phosphorus, Total Kjeldahl Nitrogen (unfiltered sample), and Total Phosphorus (unfiltered sample)

Table B'56

Data for 48-hr Tidal Study in August 1976

STATION*		HG (UG/L)	NH4A† (MG/L)	NH4B†† (MG/L)	NO2+NO3 (MG/L)	PO4 (MG/L)	TDN (MG/L)	TDP (MG/L)	TKN (MG/L)	TP (MG/L)
RLA	1	********	******	******	******	******	******	******	******	******
RLA	2	0.343	0.510	0.55	0.39	0.034	4.52	0.054	5.02	0.137
RLA	3	0.340	0.441	******	0.54	0.032	0.25	0.049	4.26	0.175
RLA	4	0.383	0.544	0.77	0.41	0.033	3.15	0.049	4.51	0.144
RLA	5	******	******	******	******	******	******	******	******	******
RLA	6	1.531	0.488	0.33	0.26	0.039	3.39	0.057	4.13	0.139
RLA	7	0.383	0.672	0.66	0.47	0.042	4.03	0.062	3.30	0.144
RLA	8	0.367	0.472	0.84	0.60	0.040	1.69	0.061	2.02	0.178
RLA	9	0.446	0.524	0.45	0.52	0.049	1.61	0.063	5.43	0.156
RLA	10	******	******	******	******	******	******	******	******	******
RLA	11	0.506	0.520	******	0.41	0.039	2.82	0.055	6.63	0.186
RLA	12	0.454	0.543	0.26	0.39	0.033	2.39	0.055	4.88	0.173
RLA	13	0.642	0.655	0.51	0.85	0.038	0.89	0.066	4.96	0.141
RLA	14	0.668	0.293	0.60	0.61	0.046	0.65	0.067	5.38	0.124
RLA	15	******	******	******	******	******	******	******	******	******
RLA	16	0.435	0.294	0.74	0.44	0.053	2.82	0.069	4.35	0.122
RLA	17	0.422	0.456	0.79	0.43	0.037	1.21	0.062	4.82	0.142
RLA	18	0.475	0.328	0.55	0.49	0.052	3.87	0.071	4.52	0.140
RLA	19	0.568	0.520	0.51	0.62	0.047	4.92	0.070	6.36	0.115
RLA	20	******	******	******	******	******	******	******	******	******
RLA	21	0.875	0.432	0.41	0.36	0.039	2.66	0.064	4.61	0.138
RLB	1	******	******	******	******	******	******	******	******	******
RLB	2	0.340	******	0.66	0.45	0.026	1.01	0.031	******	******
RLB	3	0.356	******	0.59	0.60	0.031	1.49	0.052	******	******
RLB	4	0.401	******	0.67	0.45	0.031	0.87	0.056	******	******
RLB	5	******	******	******	******	******	******	******	******	******
RLB	6	1.489	******	0.37	0.33	0.036	1.11	0.051	******	******
RLB	7	0.392	******	0.61	0.56	0.034	1.94	0.060	******	******
RLB	8	0.501	******	0.85	0.62	0.026	1.08	0.058	******	******
RLB	9	0.583	******	0.48	0.55	0.038	0.90	0.076	******	******
RLB	10	******	******	******	******	******	******	******	******	******
RLB	11	0.545	******	******	0.55	0.025	2.29	0.060	******	******
RLB	12	0.403	******	0.31	0.37	0.037	1.21	0.050	******	******
RLB	13	0.643	******	0.41	0.45	0.039	1.08	0.066	******	******
RLB	14	0.650	******	0.45	0.27	0.048	0.97	0.063	******	******
RLB	15	******	******	******	******	******	******	******	******	******
RLB	16	0.530	******	0.84	0.41	0.037	0.90	0.073	******	******
RLB	17	0.422	******	0.63	0.26	0.027	0.35	0.052	******	******
RLB	18	0.698	******	0.54	0.49	0.025	1.49	0.047	******	******
RLB	19	0.431	******	0.58	0.39	0.039	1.70	0.056	******	******
RLB	20	******	******	******	******	******	******	******	******	******
RLB	21	0.737	******	0.40	0.27	0.031	0.59	0.064	******	******

* Station
RLA = Reference marsh large channel (alpha sample), and RLB = Reference marsh small channel (beta sample)

** ****** = No data

† NH_4 A = Dissolved Ammonium, H_2SO_4 storage

†† NH_4 B = Dissolved Ammonium, $HClO_4$ storage

PARAMETERS

Dissolved Mercury, Dissolved Ammonium, Dissolved Ammonium, Dissolved Nitrate plus Nitrite, Dissolved Orthophosphate, Total Dissolved Nitrogen, Total Dissolved Phosphorus, Total Kjeldahl Nitrogen (unfiltered sample), and Total Phosphorus (unfiltered sample)

Table B'57

Data for 48-hr Tidal Study in August 1976

STATION*		HG (UG/L)	NH4A† (MG/L)	NH4B†† (MG/L)	NO2+NO3 (MG/L)	PO4 (MG/L)	TDN (MG/L)	TDP (MG/L)	TKN (MG/L)	TP (MG/L)
RSA	1	********	******	******	******	******	******	******	******	******
RSA	2	0.354	0.320	0.75	******	******	1.27	0.043	2.48	0.151
RSA	3	0.328	0.352	0.98	******	******	2.23	0.105	2.42	0.129
RSA	4	0.562	0.464	1.04	******	******	0.87	0.153	3.21	0.175
RSA	5	******	******	******	******	******	******	******	******	******
RSA	6	0.734	0.486	0.84	******	******	1.56	0.068	3.20	0.120
RSA	7	0.304	0.519	0.78	******	******	2.68	0.144	2.71	0.219
RSA	8	0.776	0.312	0.26	******	******	2.01	0.174	2.12	0.206
RSA	9	0.312	0.567	0.44	******	******	1.56	0.052	3.02	0.161
RSA	10	******	******	******	******	******	******	******	******	******
RSA	11	0.598	0.440	0.47	******	******	0.97	0.042	1.88	0.127
RSA	12	0.511	0.559	0.68	******	******	1.71	0.053	4.24	0.163
RSA	13	0.462	0.432	0.53	******	******	2.16	0.063	5.32	0.134
RSA	14	0.383	0.392	0.71	******	******	1.04	0.079	8.07	0.125
RSA	15	******	******	******	******	******	******	******	******	******
RSA	16	3.286	0.472	0.60	******	******	1.64	0.117	5.21	0.157
RSA	17	0.685	0.558	0.86	******	******	2.61	0.071	2.78	0.155
RSA	18	0.522	0.510	0.70	******	******	1.27	0.064	2.70	0.156
RSA	19	0.693	0.519	0.64	******	******	2.53	0.106	5.30	0.198
RSA	20	******	******	******	******	******	******	******	******	******
RSA	21	0.414	0.432	0.81	******	******	2.16	0.059	5.56	0.203
RSB	1	******	******	******	******	******	******	******	******	******
RSB	2	0.411	******	0.69	0.56	0.029	0.79	0.107	******	******
RSB	3	0.408	******	0.90	0.63	0.039	0.83	0.139	******	******
RSB	4	0.918	******	0.97	0.37	0.056	0.43	0.158	******	******
RSB	5	******	******	******	******	******	******	******	******	******
RSB	6	0.639	******	0.84	0.29	0.047	0.46	0.124	******	******
RSB	7	0.345	******	0.88	0.57	0.038	1.09	0.154	******	******
RSB	8	0.406	******	0.32	0.72	0.046	1.45	0.170	******	******
RSB	9	0.282	******	0.47	0.62	0.040	1.08	0.113	******	******
RSB	10	******	******	******	******	******	******	******	******	******
RSB	11	0.737	******	0.53	0.33	0.044	0.41	0.122	******	******
RSB	12	0.383	******	0.40	0.54	0.040	1.40	0.116	******	******
RSB	13	0.422	******	0.40	0.63	0.065	0.79	0.132	******	******
RSB	14	0.422	******	0.67	0.44	0.051	0.66	0.131	******	******
RSB	15	******	******	******	******	******	******	******	******	******
RSB	16	0.611	******	0.86	0.69	0.062	1.00	0.137	******	******
RSB	17	0.723	******	0.57	0.43	0.039	1.45	0.095	******	******
RSB	18	0.439	******	0.41	0.62	0.058	0.79	0.122	******	******
RSB	19	2.479	******	0.67	0.51	0.054	0.99	0.147	******	******
RSB	20	******	******	******	******	******	******	******	******	******
RSB	21	0.422	******	0.60	0.27	0.050	0.63	0.107	******	******

* Station
RSA = Reference marsh small channel (alpha sample), and RSB = Reference marsh small channel (beta sample)

** ****** = No data

† NH_4 A = Dissolved Ammonium, H_2SO_4 storage

†† NH_4 B = Dissolved Ammonium, $HClO_4$ storage

PARAMETERS

Dissolved Mercury, Dissolved Ammonium, Dissolved Ammonium, Dissolved Nitrate plus Nitrite, Dissolved Orthophosphate, Total Dissolved Nitrogen, Total Dissolved Phosphorus, Total Kjeldahl Nitrogen (unfiltered sample), and Total Phosphorus (unfiltered sample)

Table B'58

Data for 48-hr Tidal Study in August 1976

STATION*	TIME	DCA (MG/L)	DFE (MG/L)	DMN (MG/L)	DZN (MG/L)
APA 1	0720	16.2	0.39	0.124	0.095
APA 2	0820	13.1	0.98	0.071	0.051
APA 3	0925	15.3	0.28	0.041	0.031
APA 4	1035	13.1	0.09	0.018	0.040
APA 5	1150	15.0	0.08	0.044	0.087
APA 6	1300	14.3	0.19	0.062	0.260
APA 7	1335	********	******	******	******
APA 8	1445	15.9	0.32	0.146	0.055
APA 9	1610	20.2	0.97	0.379	0.102
APA 10	1655	20.6	2.66	0.518	0.085
APA 11	1745	21.2	2.10	0.554	0.098
APA 12	1825	21.5	1.10	0.461	0.050
APA 13	1920	16.5	0.83	0.131	0.057
APA 14	2025	15.9	0.20	0.031	0.033
APA 15	2130	15.6	0.35	0.290	0.025
APA 16	2240	15.3	0.23	0.235	0.087
APA 17	2350	14.6	0.10	0.024	0.062
APA 18	0145	15.3	0.53	0.164	0.039
APA 19	0300	15.9	0.56	0.136	0.046
APA 20	0420	15.9	0.27	0.135	0.072
APA 21	0515	18.7	1.06	0.376	0.051
APA 22	0621	20.2	0.54	0.568	0.099
APA 23	0715	17.1	0.83	0.403	0.059
APA 24	0750	16.2	0.45	0.325	0.032
APA 25	0857	16.2	0.21	0.067	0.036
APA 26	1000	15.9	0.23	0.030	0.035
APA 27	1046	13.7	0.11	0.018	0.069
APA 28	1200	15.6	0.17	0.035	0.033
APA 29-1†	1251	14.0	0.31	0.050	0.043
APA 29-2	1345	15.3	0.25	0.055	0.089
APA 30	1445	14.6	0.12	0.075	0.101
APA 31	1550	16.8	0.56	0.193	0.046
APA 32	1700	19.9	0.32	0.426	0.116
APA 33	1745	19.3	0.31	0.405	0.069
APA 34	1806	21.2	2.30	0.570	0.044
APA 35	1900	22.4	2.20	1.730	0.178
APA 36	2130	16.2	0.48	0.160	0.107
APA 37	2230	15.3	0.45	0.060	0.143
APA 38	2345	15.6	0.22	0.044	0.041
APA 39	0130	15.6	0.27	0.075	0.117
APA 40	0215	15.9	0.08	0.098	0.080
APA 41	0305	11.8	0.27	0.070	0.066
APA 42	0400	16.8	0.27	0.113	0.090
APA 43	0610	19.9	0.85	0.394	0.056
APA 44	0630	17.4	0.57	0.302	0.041
APA 45	0750	20.9	0.79	0.487	0.133
APA 46	****	******	******	******	******
APA 47	****	******	******	******	******
APA 48	****	******	******	******	******

* Station
APA = Artificial Habitat Development Site pipe (alpha sample only)

** ****** = No data

† APA 29-1, APA 29-2 = Error during shift change

PARAMETERS

Dissolved Calcium, Dissolved Iron, Dissolved Manganese, and Dissolved Zinc

Table B'59

Data for 48-hr Tidal Study in August 1976

STATION*	TIME	DCA (MG/L)	DFE (MG/L)	DMN (MG/L)	DZN (MG/L)
APB 1	0720	13.6	0.16	0.062	0.044
APB 2	0820	14.5	0.62	0.075	0.055
APB 3	0925	14.9	0.14	0.018	0.057
APB 4	1035	14.5	0.29	0.033	0.066
APB 5	1150	13.6	0.09	0.042	0.025
APB 6	1300	16.6	********	0.079	******
APB 7	1335	16.2	0.48	0.104	0.052
APB 8	1445	19.1	1.34	0.200	0.057
APB 9	1610	20.5	0.61	0.369	0.173
APB 10	1655	20.6	4.06	0.580	0.056
APB 11	1745	22.5	2.20	0.541	0.071
APB 12	1825	20.6	0.28	0.734	0.139
APB 13	1920	17.5	0.45	0.135	0.170
APB 14	2025	16.3	0.34	0.054	0.044
APB 15	2130	16.5	0.69	0.096	0.154
APB 16	2240	16.6	0.06	0.019	0.090
APB 17	2350	16.6	0.34	0.062	0.076
APB 18	0145	15.9	0.65	0.154	0.048
APB 19	0300	15.7	0.59	0.126	0.039
APB 20	0420	17.3	0.55	0.141	0.045
APB 21	0515	18.6	1.76	0.332	0.125
APB 22	0621	21.2	0.39	0.520	0.024
APB 23	0715	22.2	1.06	0.459	0.052
APB 24	0750	20.2	0.81	0.359	0.110
APB 25	0857	17.1	0.28	0.065	0.085
APB 26	1000	14.9	0.10	0.014	0.032
APB 27	1046	15.9	0.13	0.029	0.044
APB 28	1200	14.8	0.20	0.033	0.061
APB 29-1+	1251	16.0	0.23	0.040	0.026
APB 29-2	1345	15.3	0.36	0.048	0.042
APB 30	1445	16.1	0.62	0.292	0.056
APB 31	1550	19.3	1.14	0.210	0.055
APB 32	1700	18.4	0.26	0.402	0.055
APB 33	1745	19.8	0.34	0.476	0.052
APB 34	1806	22.4	1.92	0.524	0.105
APB 35	1900	23.3	2.06	0.727	0.058
APB 36	2130	16.8	0.32	0.060	0.040
APB 37	2230	8.0	0.11	0.021	0.065
APB 38	2345	13.4	0.29	0.062	0.060
APB 39	0130	15.8	0.16	0.035	0.055
APB 40	0215	13.6	0.15	0.065	0.019
APB 41	0305	17.5	0.64	0.184	******
APB 42	0400	14.9	0.32	0.269	0.027
APB 43	0610	20.9	1.09	0.431	0.071
APB 44	0630	19.9	0.48	0.384	0.117
APB 45	0750	******	******	******	******
APB 46	****	******	******	******	******
APB 47	****	******	******	******	******
APB 48	****	******	******	******	******

* Station
APB = Artificial Habitat Development Site pipe (beta sample only)

** ****** = No data

+ APB 29-1, APB 29-2 = Error during shift change

PARAMETERS

Dissolved Calcium, Dissolved Iron, Dissolved Manganese, and Dissolved Zinc

Table B'60

Data for 48-hr Tidal Study in August 1976

STATION*	TIME	DCA (MG/L)	DFE (MG/L)	DMN (MG/L)	DZN (MG/L)
ABA 1	0700	15.7	0.50	0.305	0.053
ABA 2	0910	14.0	0.28	0.095	0.060
ABA 3	0915	14.3	0.20	0.090	0.109
ABA 4	1015	14.8	0.23	0.073	0.042
ABA 5	1130	14.8	0.31	0.112	0.032
ABA 6	1215	13.0	0.16	0.135	0.091
ABA 7	1320	********	0.24	0.184	0.180
ABA 8	1420	14.8	0.36	0.307	0.190
ABA 9	1555	******	******	******	******
ABA 10	1645	******	******	******	******
ABA 11	1730	******	******	******	******
ABA 12	****	******	******	******	******
ABA 13	1900	16.7	0.31	0.357	0.081
ABA 14	2015	15.7	0.39	0.141	0.114
ABA 15	2100	14.6	0.50	0.251	0.127
ABA 16	2220	15.2	0.21	0.086	0.145
ABA 17	2325	14.4	0.19	0.147	0.072
ABA 18	0125	15.1	0.52	0.205	0.112
ABA 19	0233	9.5	0.20	0.158	0.090
ABA 20	0406	******	0.68	0.421	0.107
ABA 21	0447	17.9	0.23	0.644	0.119
ABA 22	0621	******	******	******	******
ABA 23	0715	******	******	******	******
ABA 24	0750	******	******	******	******
ABA 25	0842	15.9	0.22	0.133	0.055
ABA 26	0945	14.3	0.16	0.073	0.051
ABA 27	1033	15.7	0.11	0.047	0.090
ABA 28	1145	14.8	0.17	0.082	0.209
ABA 29-1 †	1235	14.9	0.26	0.104	0.040
ABA 29-2	1325	15.2	0.13	0.049	0.042
ABA 30	1430	16.7	0.60	0.494	0.051
ABA 31	1530	17.0	0.28	0.510	0.117
ABA 32	****	******	******	******	******
ABA 33	****	******	******	******	******
ABA 34	****	******	******	******	******
ABA 35	****	******	******	******	******
ABA 36	2100	14.4	0.23	0.097	0.042
ABA 37	2200	13.8	0.19	0.061	0.137
ABA 38	2330	15.6	0.35	0.142	0.122
ABA 39	0100	15.4	0.35	0.212	0.080
ABA 40	0150	14.6	0.28	0.118	0.049
ABA 41	0245	14.9	0.22	0.332	0.103
ABA 42	0335	14.8	0.23	0.270	0.053
ABA 43	0550	******	******	******	******
ABA 44	0620	******	******	******	******
ABA 45	0700	******	******	******	******
ABA 46	****	******	******	******	******
ABA 47	****	******	******	******	******
ABA 48	****	******	******	******	******

* Station
ABA = Artificial Habitat Development Site breach (alpha sample only)

** ****** = No data

† ABA 29-1, ABA 29-2 = Error during shift change

PARAMETERS
Dissolved Calcium, Dissolved Iron, Dissolved Manganese, and Dissolved Zinc

Table B'61

Data for 48-hr Tidal Study in August 1976

STATION*	TIME	DCA (MG/L)	DFE (MG/L)	DMN (MG/L)	DZN (MG/L)
ABB 1	0700	16.1	0.25	0.030	0.121
ABB 2	0810	13.7	0.31	0.034	0.106
ABB 3	0915	12.1	0.13	0.022	0.099
ABB 4	1015	13.6	0.09	0.016	0.061
ABB 5	1130	16.1	0.24	0.043	0.092
ABB 6	1215	******[**]	******	******	******
ABB 7	1320	16.2	0.48	0.082	0.294
ABB 8	1420	17.1	1.13	0.158	0.271
ABB 9	1555	******	******	******	******
ABB 10	1645	******	******	******	******
ABB 11	1730	******	******	******	******
ABB 12	****	******	******	******	******
ABB 13	1900	14.4	0.28	0.126	0.540
ABB 14	2015	15.5	0.25	0.043	0.118
ABB 15	2100	17.0	0.32	******	0.101
ABB 16	2220	15.3	0.07	0.079	0.098
ABB 17	2325	14.6	0.32	0.026	0.094
ABB 18	0125	14.9	0.48	0.073	0.144
ABB 19	0233	14.8	0.64	0.106	0.086
ABB 20	0406	16.8	0.16	0.119	0.096
ABB 21	0447	16.7	0.56	0.168	0.243
ABB 22	0621	******	******	******	******
ABB 23	0715	******	******	******	******
ABB 24	0750	******	******	******	******
ABB 25	0842	14.9	0.07	0.087	0.084
ABB 26	0945	16.2	0.05	0.043	0.190
ABB 27	1033	17.4	0.38	0.036	0.086
ABB 28	1145	15.8	0.16	0.013	0.071
ABB 29-1 [†]	1235	15.2	0.16	0.016	0.124
ABB 29-2	1325	16.3	0.37	0.067	0.162
ABB 30	1430	17.8	0.29	0.118	0.045
ABB 31	1530	16.9	0.24	0.116	0.186
ABB 32	****	******	******	******	******
ABB 33	****	******	******	******	******
ABB 34	****	******	******	******	******
ABB 35	****	******	******	******	******
ABB 36	2100	13.8	0.22	0.033	0.112
ABB 37	2200	16.3	0.26	0.050	0.195
ABB 38	2330	10.3	0.11	0.011	0.103
ABB 39	0100	16.1	0.21	0.017	0.166
ABB 40	0150	14.7	0.25	0.027	0.221
ABB 41	0245	15.4	0.24	0.081	0.114
ABB 42	0335	14.8	0.41	0.119	0.084
ABB 43	0550	******	******	******	******
ABB 44	0620	******	******	******	******
ABB 45	0700	******	******	******	******
ABB 46	****	******	******	******	******
ABB 47	****	******	******	******	******
ABB 48	****	******	******	******	******

* Station
ABB = Artificial Habitat Development Site breach (beta sample only)

** ****** = No data

† ABB 29-1, ABB 29-2 = Error during shift change

PARAMETERS

Dissolved Calcium, Dissolved Iron, Dissolved Manganese, and Dissolved Zinc

Table B'62

Data for 48-hr Tidal Study in August 1976

STATION*	TIME	DCA (MG/L)	DFE (MG/L)	DMN (MG/L)	DZN (MG/L)
RLA 1	0745	13.7	0.34	0.050	0.031
RLA 2	0840	15.1	0.36	0.043	0.092
RLA 3	0945	16.5	0.37	0.044	0.034
RLA 4	1110	15.8	0.13	0.019	0.074
RLA 5	1145	16.2	0.17	0.023	0.035
RLA 6	1245	****** **	******	******	******
RLA 7	1345	16.4	0.16	0.031	0.041
RLA 8	1445	16.2	0.31	0.061	0.076
RLA 9	1545	16.2	0.34	0.069	0.036
RLA 10	1645	12.0	0.34	0.042	0.046
RLA 11	1745	16.4	0.10	0.048	0.324
RLA 12	1845	13.2	0.08	0.007	0.063
RLA 13	1945	16.7	0.31	0.040	0.051
RLA 14	2045	16.7	0.25	0.037	0.041
RLA 15	2145	15.4	0.29	0.043	0.048
RLA 16	2245	16.4	0.31	0.045	0.071
RLA 17	2345	16.5	0.20	0.034	0.072
RLA 18	0045	16.7	0.25	0.034	0.032
RLA 19	0145	16.2	0.18	0.031	0.034
RLA 20	0245	13.8	0.29	0.080	0.063
RLA 21	0345	12.1	0.21	0.031	0.064
RLA 22	0445	16.6	0.45	0.064	0.195
RLA 23	0545	15.9	0.59	0.086	0.016
RLA 24	0645	16.1	0.29	0.062	0.122
RLA 25	0745	15.8	0.39	0.059	0.091
RLA 26	0845	15.8	0.29	0.044	0.041
RLA 27	0945	15.6	0.26	0.036	0.072
RLA 28	1045	******	******	******	******
RLA 29	1145	15.8	0.24	0.038	0.077
RLA 30	1245	16.4	0.27	0.018	0.053
RLA 31	1345	15.4	0.19	0.019	0.063
RLA 32	1445	16.9	0.12	0.019	0.061
RLA 33	1545	15.5	0.24	0.084	0.106
RLA 34	1645	16.4	0.24	0.021	0.036
RLA 35	1745	14.8	0.29	0.029	0.072
RLA 36	1845	16.8	0.35	0.036	0.066
RLA 37	1945	14.7	0.47	0.060	0.066
RLA 38	2045	14.0	0.27	0.037	0.058
RLA 39	2145	9.3	0.16	0.013	0.053
RLA 40	2245	15.2	0.21	0.037	0.032
RLA 41	2345	9.8	0.18	0.050	0.024
RLA 42	0045	16.7	0.36	0.052	0.016
RLA 43	0145	15.2	0.21	0.036	0.124
RLA 44	0245	14.5	0.30	0.061	0.031
RLA 45	0345	16.6	0.41	0.063	0.031
RLA 46	0445	16.0	0.33	0.077	0.052
RLA 47	0545	14.7	0.36	0.086	0.074
RLA 48	0645	16.5	0.45	0.040	0.093
RLA 49	0745	15.9	0.16	******	0.058

* Station
RLA = Reference marsh large channel (alpha sample only)

** ****** = No data

PARAMETERS

Dissolved Calcium, Dissolved Iron, Dissolved Manganese, and Dissolved Zinc

Table B'63

Data for 48-hr Tidal Study in August 1976

STATION*	TIME	DCA (MG/L)	DFE (MG/L)	DMN (MG/L)	DZN (MG/L)
RLB 1	0745	13.9	0.22	0.038	0.046
RLB 2	0840	12.6	0.14	0.018	0.098
RLB 3	0945	12.9	0.36	0.044	0.058
RLB 4	1110	13.6	0.16	0.023	0.060
RLB 5	1145	13.8	0.22	0.027	0.064
RLB 6	1245	12.5	0.17	0.033	0.059
RLB 7	1345	13.7	0.22	0.039	0.093
RLB 8	1445	13.8	0.22	0.050	0.095
RLB 9	1545	14.0	0.41	0.064	0.069
RLB 10	1645	14.4	0.43	0.066	0.157
RLB 11	1745	13.5	0.37	0.046	0.086
RLB 12	1845	13.6	0.25	0.020	0.055
RLB 13	1945	12.9	0.33	0.045	0.070
RLB 14	2045	12.9	0.15	0.019	0.065
RLB 15	2145	12.9	0.17	0.028	0.152
RLB 16	2245	13.1	0.18	0.039	0.069
RLB 17	2345	12.4	0.17	0.032	0.043
RLB 18	0045	12.9	0.22	0.032	0.046
RLB 19	0145	12.6	0.28	0.041	0.114
RLB 20	0245	12.6	0.21	0.034	0.082
RLB 21	0345	13.4	0.35	0.051	0.054
RLB 22	0445	13.4	0.25	0.050	0.072
RLB 23	0545	13.0	0.34	0.050	0.052
RLB 24	0645	12.6	0.32	0.053	0.034
RLB 25	0745	12.7	0.38	0.044	0.044
RLB 26	0845	13.0	0.41	0.054	0.100
RLB 27	0945	13.4	0.22	0.035	0.063
RLB 28	1045	12.4	0.25	0.031	0.098
RLB 29	1145	13.9	0.24	0.042	0.181
RLB 30	1245	14.2	0.19	0.020	0.226
RLB 31	1345	14.9	0.12	0.016	0.118
RLB 32	1445	15.6	0.17	0.071	0.229
RLB 33	1545	12.4	0.26	0.055	0.059
RLB 34	1645	14.6	0.43	0.085	0.131
RLB 35	1745	13.5	0.26	0.027	0.075
RLB 36	1845	14.3	0.37	0.034	0.267
RLB 37	1945	10.5	0.35	0.049	0.055
RLB 38	2045	11.4	0.22	0.046	0.049
RLB 39	2145	********	******	******	******
RLB 40	2245	10.9	0.15	0.034	0.045
RLB 41	2345	12.5	0.15	0.025	0.042
RLB 42	0045	13.6	0.25	0.042	0.030
RLB 43	0145	7.3	0.20	0.022	0.072
RLB 44	0245	11.3	0.23	0.032	0.155
RLB 45	0345	12.5	0.50	0.070	0.091
RLB 46	0445	12.9	0.45	0.068	0.098
RLB 47	0545	11.5	0.45	0.073	0.171
RLB 48	0645	10.1	0.38	0.075	0.158
RLB 49	0745	14.5	0.45	0.098	0.075

* Station
RLB = Reference marsh large channel (beta sample only)

** ****** = No data

PARAMETERS

Dissolved Calcium, Dissolved Iron, Dissolved Manganese, and Dissolved Zinc

Table B'64

Data for 48-hr Tidal Study in August 1976

STATION*	TIME	DCA (MG/L)	DFE (MG/L)	DMN (MG/L)	DZN (MG/L)
RSA 1	0755	14.0	0.35	0.033	0.119
RSA 2	0855	14.0	0.07	0.053	0.061
RSA 3	0955	13.2	0.25	0.106	0.040
RSA 4	1055	13.8	0.17	0.053	0.065
RSA 5	1155	13.6	0.14	0.041	0.039
RSA 6	1255	12.8	0.18	0.030	0.089
RSA 7	1355	********	******	******	******
RSA 8	1455	13.4	0.27	0.054	0.117
RSA 9	1555	13.6	0.28	******	0.051
RSA 10	1650	14.6	0.17	0.056	0.181
RSA 11	1810	13.4	0.44	0.030	0.060
RSA 12	1850	12.6	0.24	0.011	0.070
RSA 13	1950	12.8	0.10	0.025	0.055
RSA 14	2050	13.6	0.35	0.032	0.150
RSA 15	2150	13.4	0.14	0.019	0.120
RSA 16	2250	13.2	0.19	0.023	0.060
RSA 17	2350	13.6	0.08	0.043	0.030
RSA 18	0050	13.4	0.09	0.020	0.060
RSA 19	0155	******	******	0.057	******
RSA 20	0255	13.0	0.22	0.052	0.118
RSA 21	0345	13.4	0.42	0.053	0.090
RSA 22	0445	12.2	0.37	0.067	0.077
RSA 23	0545	12.6	0.33	0.095	0.112
RSA 24	0645	13.0	0.32	0.034	0.055
RSA 25	0745	******	******	0.039	******
RSA 26	0845	14.2	0.24	0.048	0.054
RSA 27	0945	14.2	0.34	0.039	0.088
RSA 28	1045	13.6	0.31	0.029	0.047
RSA 29	1145	14.0	0.20	0.029	0.050
RSA 30	1245	12.0	0.09	0.039	0.050
RSA 31	1400	14.4	0.19	0.034	0.072
RSA 32	1450	14.4	0.29	0.085	0.090
RSA 33	1550	14.2	0.28	0.020	0.136
RSA 34	1730	14.8	0.24	0.037	0.154
RSA 35	****	******	******	******	******
RSA 36	****	******	******	******	******
RSA 37	2000	14.6	0.39	0.050	0.094
RSA 38	2050	10.2	0.30	0.032	0.063
RSA 39	2150	14.6	0.41	******	0.028
RSA 40	2300	11.6	0.18	******	0.142
RSA 41	2350	13.6	0.25	0.038	0.093
RSA 42	0050	11.0	0.24	0.052	0.092
RSA 43	0155	12.4	0.21	0.040	0.074
RSA 44	0300	13.0	0.34	0.041	0.098
RSA 45	0355	14.0	0.40	0.065	0.046
RSA 46	0455	14.4	0.58	0.076	0.044
RSA 47	0555	10.6	0.42	0.149	0.066
RSA 48	0655	10.4	0.44	0.094	0.192
RSA 49	0755	12.2	0.37	0.050	0.055

* Station

RSA = Reference marsh small channel (alpha sample only)

** ****** = No data

PARAMETERS

Dissolved Calcium, Dissolved Iron, Dissolved Manganese, and Dissolved Zinc

Table B'65

Data for 48-hr Tidal Study in August 1976

STATION*	TIME	DCA (MG/L)	DFE (MG/L)	DMN (MG/L)	DZN (MG/L)
RSB 1	0755	14.5	0.32	0.033	0.046
RSB 2	0855	14.6	0.35	0.053	0.024
RSB 3	0955	12.3	0.27	0.106	0.075
RSB 4	1055	15.3	0.18	0.053	0.131
RSB 5	1155	14.9	0.10	0.041	0.168
RSB 6	1255	12.5	0.21	0.030	0.041
RSB 7	1355	********	******	******	******
RSB 8	1455	15.5	0.34	0.054	0.043
RSB 9	1555	14.2	0.29	******	0.066
RSB 10	1650	14.9	0.30	0.056	0.059
RSB 11	1810	14.2	0.27	0.038	0.068
RSB 12	1850	11.9	0.11	0.011	0.027
RSB 13	1950	14.5	0.20	0.025	0.042
RSB 14	2050	14.2	0.21	0.032	0.066
RSB 15	2150	15.2	0.14	0.019	0.059
RSB 16	2250	13.7	0.18	0.023	0.029
RSB 17	2350	15.9	0.25	0.043	0.088
RSB 18	0050	13.6	0.14	0.020	0.033
RSB 19	0155	10.7	0.35	0.057	0.059
RSB 20	0255	14.2	0.32	0.052	0.111
RSB 21	0345	13.8	0.21	0.053	0.051
RSB 22	0445	11.6	0.34	0.067	0.049
RSB 23	0545	11.8	0.39	0.085	0.058
RSB 24	0645	9.7	0.21	0.034	0.128
RSB 25	0745	10.0	0.23	0.039	0.047
RSB 26	0845	10.7	0.25	0.048	0.041
RSB 27	0945	12.2	0.25	0.038	0.028
RSB 28	1045	13.8	0.17	0.029	0.049
RSB 29	1145	13.2	0.17	0.029	0.029
RSB 30	1245	15.1	0.21	0.039	0.196
RSB 31	1400	15.3	0.18	0.034	0.143
RSB 32	1450	14.5	0.23	0.085	0.115
RSB 33	1550	15.1	0.11	0.020	0.129
RSB 34	1730	13.8	0.31	0.037	0.084
RSB 35	****	******	******	******	******
RSB 36	****	******	******	******	******
RSB 37	2000	13.4	0.24	0.050	0.039
RSB 38	2050	12.7	0.13	0.032	0.075
RSB 39	2150	******	******	******	******
RSB 40	2300	******	******	******	******
RSB 41	2350	11.6	0.23	0.038	0.070
RSB 42	0050	13.4	0.25	0.052	0.116
RSB 43	0155	13.4	0.32	0.040	0.039
RSB 44	0300	10.1	0.25	0.041	0.049
RSB 45	0355	9.7	0.26	0.065	0.071
RSB 46	0455	11.1	0.52	0.076	0.053
RSB 47	0555	11.9	0.43	0.149	0.148
RSB 48	0655	13.3	0.37	0.094	0.032
RSB 49	0755	14.0	0.29	0.050	0.110

* Station

RSB = Reference marsh small channel (beta sample only)

** ****** = No data

PARAMETERS

Dissolved Calcium, Dissolved Iron, Dissolved Manganese, and Dissolved Zinc

Table B'66

Data for 48-hr Tidal Study in August 1976

PARTICULATE METALS----AUGUST 1976
(UG/G)

*STA/TIDE**		CA	CD	CU	FE	MN	NI	PB	ZN
AP	LS	3500	2.4	38.1	44040	1270	32	62	232
AP	F	3550	4.8	21.7	52180	1740	39	81	300
AP	HS	3920	15.0	6.6	58220	1840	79	96	288
AP	E	3100	5.4	23.2	49370	1240	63	77	245
AP	PWD	2710	2.6	33.7	49070	1130	37	62	256
AB	F	4130	22.0	5.5	50140	2190	117	92	383
AB	HS	4483	22.0	252.	65290	2110	202	120	610
AB	E	4220	9.6	151.	57560	1530	85	89	326
RL	LS	4850	6.2	8.6	52290	7660	153	77	149
RL	F	4460	9.3	30.0	43970	2450	37	83	288
RL	HS	5770	10.0	34.4	53320	2990	106	98	202
RL	E	4720	17.0	102.	46710	2410	165	95	196
RS	LS	4010	5.6	21.2	49410	2620	49	72	103
RS	F	3070	7.4	25.7	31340	1750	64	64	193
RS	HS	4740	7.9	77.9	54790	2660	68	140	215
RS	E	4220	8.8	59.6	50695	2150	213	320	182

* Station
AP = Artificial Habitat Development Site Pipe, AB = Artificial Habitat Development Site Breach, RL = Reference marsh large channel, and RS = Reference marsh small channel

** Tide
LS = Low Slack Water, F = Flood, HS = High Slack Water, E = Ebb, and PWD = Pore Water Drainage (end of ebb tide at AP only)

PARAMETERS

Cadmium, Copper, Iron, Manganese, Nickel, Lead, and Zinc

Table B'67

Silt/Clay Ratios for Suspended Sediments from the Artificial Habitat Development Site Pipe (AP) and a Reference Marsh (RS) Collected in August 1976

Site	James River Water	H_2O_2 Treated Dispersed in Deionized Water	Time	Date
AP-23	3.4	---	0600	Aug 6
-24	5.2	---	0700	
-25	0.5	0.4	0800	
-26	1.0	1.8	0900	
-27	0.4	0.7	1000	
-28	14.9	1.2	1100	
-30	1.4	2.4	1300	
-31	3.3	2.2	1400	
-33	3.8	1.0	1600	
-35	1.7	1.9	1800	
-36	1.7	2.7	1900	
-37	21.7	2.2	2000	
-40	2.5	0.5	2300	
-41	1.1	1.2	2400	
-42	0.7	3.9	0100	Aug 7
-43	1.6	2.6	0200	
Mean	4.1	1.7		
Std. Dev.	± 5.9	1.0		
RS-16	0.8	0.8	2300	Aug 5
-17	1.6	0.5	2400	
-18	---	1.1	0100	Aug 6
-19	1.8	0.9	0200	
-20	0.5	0.6	0300	
-21	0.3	5.2	0400	
-22	1.5	0.8	0500	
-23	1.7	0.7	0600	
-25	0.8	0.5	0800	
-26	4.5	---	0900	
-27	0.1	3.4	1000	
-29	0.9	0.9	1200	
-30	---	---	---	
-31	0.3	0.4	1400	
-32	1.7	2.0	1500	
-33	1.0	1.1	1600	
-34	1.7	0.4	1700	
-37	---	0.7	2000	
-38	0.1	1.9	2100	
-39	0.5	1.9	2200	
-41	1.5	1.5	2400	
-42	---	---	---	Aug 7
-43	1.0	1.1	0200	
-48	0.4	1.1	0700	
Mean	1.1	1.3		
Std. Dev.	± 1.0	±1.2		

Table B'68

Data for 54-hr Tidal Study in January 1977

STATION*	TIME	TEMP (C)	PH	COND (MMHO/CM)	TURB (FTU)	SUSP SOL (MG/L)	DISS O2 (MG/L)	O2 SAT (%)
AP 1	1340	3.5	7.44	0.139	39.	54.	12.09	92.37
AP 2	1426	3.4	7.46	0.230	29.	51.	12.23	93.19
AP 3	1526	2.5	7.46	0.141	7.	42.	12.07	89.78
AP 4	1534	2.0	7.56	0.144	11.	43.	12.10	88.78
AP 5	1815	0.6	7.40	0.140	12.	22.	10.10	71.86
AP 6	1935	-0.4	7.28	0.136	14.	27.	11.69	80.21
AP 7	2035	-0.1	7.40	0.153	17.	23.	11.02	76.26
AP 8	2120	-0.2	7.30	0.489	18.	47.	11.32	78.12
AP 9	2230	-0.3	7.30	0.167	18.	293.	11.64	80.10
AP 10	2330	0.0	7.90	0.183	28.	64.	11.57	80.30
AP 11	0015	-0.2	7.60	0.175	********	51.	11.10	76.60
AP 12	0107	-0.1	7.80	0.172	28.	43.	11.82	81.80
AP 13	0212	-0.1	8.00	0.148	11.	24.	11.42	79.03
AP 14	0315	0.0	7.90	0.148	10.	21.	10.92	75.79
AP 15	0415	-0.1	7.80	0.147	7.	21.	10.19	70.52
AP 16	0625	0.1	7.42	0.354	12.	21.	11.30	78.65
AP 17	0730	0.0	7.39	0.177	12.	12.	10.54	73.15
AP 18	0825	0.0	7.33	0.187	14.	16.	10.61	73.63
AP 19	0920	0.2	7.31	0.188	25.	*****	11.27	78.66
AP 20	1025	0.1	7.43	0.183	42.	36.	11.44	79.62
AP 21	1145	-0.1	7.43	0.163	*****	32.	12.08	83.60
AP 22	1215	0.4	7.43	0.159	18.	22.	11.42	80.16
AP 23	1315	3.3	7.37	0.155	12.	*****	11.61	88.23
AP 24	1420	2.6	7.42	0.145	25.	42.	11.23	83.75
AP 25	1511	1.4	7.42	0.163	18.	32.	11.36	81.99
AP 26	1620	0.2	7.47	0.143	14.	*****	11.51	80.33
AP 27	1730	0.5	7.50	0.145	14.	24.	10.73	75.53
AP 28	1815	0.5	7.50	0.152	12.	31.	11.23	79.04
AP 29	2030	******	7.90	0.159	31.	22.	8.52	******
AP 30	2230	0.4	7.60	0.130	35.	61.	12.18	85.49
AP 31	2345	0.3	7.31	0.182	40.	47.	12.49	87.42
AP 32	0025	0.7	7.32	0.134	22.	19.	12.65	89.54
AP 33	0135	1.0	7.16	0.139	16.	23.	11.41	81.44
AP 34	0230	1.0	7.21	0.134	14.	17.	10.42	74.30
AP 35	0325	0.8	7.22	0.135	14.	39.	9.88	70.13
AP 36	0440	0.9	7.18	0.365	14.	35.	10.40	74.60
AP 37	0555	0.4	7.26	0.133	11.	24.	12.03	84.44
AP 38	0705	0.4	7.19	0.135	15.	17.	11.85	83.17
AP 39	0800	1.4	7.18	0.153	10.	19.	******	******
AP 40	0845	0.0	6.88	0.193	14.	8.	11.69	82.90
AP 41	1000	0.9	6.98	0.127	11.	17.	12.08	85.99
AP 42	1130	3.6	7.10	0.135	67.	157.	11.22	85.95
AP 43	1215	4.2	7.10	0.111	32.	131.	******	******
AP 44	1315	4.2	******	0.141	50.	109.	12.40	97.13
AP 45	1415	2.0	******	0.147	40.	100.	11.67	87.51
AP 46	1515	3.4	******	0.193	56.	147.	11.31	86.18
AP 47	1617	3.1	******	0.146	105.	274.	12.03	90.94
AP 48	1715	2.4	******	0.143	120.	739.	12.49	92.65
AP 49	****	******	******	******	*****	*****	******	******
AP 50	****	******	******	******	*****	*****	******	******
AP 51	****	******	******	******	*****	*****	******	******
AP 52	****	******	******	******	*****	*****	******	******
AP 53	****	******	******	******	*****	*****	******	******

* Station
AP = Artificial Habitat Development Site pipe

** ****** = No data

PARAMETERS

Temperature, pH, Conductivity, Turbidity, Suspended Solids, Dissolved Oxygen, and Percent Oxygen Saturation

Table B'69

Data for 54-hr Tidal Study in January 1977

STATION*	TIME	TEMP (C)	PH	COND (MMHO/CM)	TURB (FTU)	SUSP SOL (MG/L)	DISS O2 (MG/L)	O2 SAT (%)
AB 1	1310	3.4	7.59	0.147	24.	48.	12.22	93.12
AB 2	1415	3.1	7.42	0.319	25.	40.	12.23	92.45
AB 3	1512	1.2	7.49	0.151	9.	21.	11.89	85.34
AB 4	1623	2.1	7.52	0.146	10.	20.	10.88	80.05
AB 5	1750	1.6	7.51	0.310	6.	20.	11.61	84.26
AB 6	1910	0.0	7.49	0.138	10.	18.	11.93	82.80
AB 7	2020	-0.2	7.29	0.140	13.	33.	10.34	71.35
AB 8	2110	-0.2	********	******	*****	*****	******	******
AB 9	2215	-0.2	******	******	*****	*****	******	******
AB 10	2335	******	******	******	*****	*****	11.57	******
AB 11	0005	******	******	******	20.	*****	******	******
AB 12	0100	******	******	******	*****	*****	******	******
AB 13	0212	******	******	******	*****	*****	******	******
AB 14	0302	0.1	7.90	0.156	7.	36.	******	******
AB 15	0405	0.1	7.90	0.156	7.	23.	11.11	77.32
AB 16	0606	0.1	7.28	0.173	11.	8.	10.74	74.75
AB 17	0708	0.0	7.34	0.333	10.	17.	9.76	67.74
AB 18	0808	-0.1	7.48	0.267	14.	19.	10.92	75.57
AB 19	0906	******	******	******	*****	*****	******	******
AB 20	1008	******	******	******	*****	*****	******	******
AB 21	1130	******	******	******	*****	*****	******	******
AB 22	1212	******	******	******	*****	*****	******	******
AB 23	1310	2.2	7.39	0.161	30.	*****	11.32	83.52
AB 24	1400	2.3	7.50	0.146	14.	22.	******	******
AB 25	1500	1.4	7.20	0.421	30.	40.	11.24	81.12
AB 26	1600	1.4	7.50	0.139	10.	18.	10.95	79.03
AB 27	1715	0.7	7.90	0.139	10.	29.	10.59	74.96
AB 28	1800	0.4	7.50	0.140	13.	29.	11.56	81.14
AB 29	2000	******	7.49	0.139	14.	29.	11.50	******
AB 30	2210	******	******	******	*****	*****	******	******
AB 31	2330	******	******	******	*****	*****	******	******
AB 32	0013	******	******	******	*****	*****	******	******
AB 33	0105	1.2	7.11	0.384	12.	22.	11.06	79.38
AB 34	0210	1.2	7.08	0.140	15.	21.	11.26	80.82
AB 35	0310	1.2	7.24	0.268	9.	26.	11.33	81.32
AB 36	0415	1.2	7.19	0.139	12.	9.	11.36	81.54
AB 37	0530	1.1	7.30	0.287	12.	20.	11.67	83.53
AB 38	0650	0.4	7.14	0.154	12.	17.	12.08	84.79
AB 39	0730	1.2	7.25	0.132	12.	34.	12.02	86.28
AB 40	0835	0.8	6.88	0.131	12.	20.	12.02	85.32
AB 41	0930	0.9	6.98	0.148	11.	16.	12.16	86.55
AB 42	1120	2.4	******	******	*****	*****	******	******
AB 43	1200	******	******	******	*****	*****	******	******
AB 44	1300	******	******	******	*****	*****	******	******
AB 45	1400	2.7	******	0.156	42.	79.	12.48	93.33
AB 46	1500	2.3	******	0.184	50.	75.	******	******
AB 47	1600	2.0	******	0.147	28.	71.	12.61	92.53
AB 48	1700	2.5	******	0.142	44.	95.	12.58	93.57
AB 49	****	******	******	******	*****	*****	******	******
AB 50	****	******	******	******	*****	*****	******	******
AB 51	****	******	******	******	*****	*****	******	******
AB 52	****	******	******	******	*****	*****	******	******
AB 53	****	******	******	******	*****	*****	******	******

* Station
AB = Artificial Habitat Development Site breach

** ****** = No data

PARAMETERS

Temperature, pH, Conductivity, Turbidity, Suspended Solids, Dissolved Oxygen, and Percent Oxygen Saturation

Table B'70

Data for 54-hr Tidal Study in January 1977

STATION*	TIME	TEMP (C)	PH	CONC (MMHO/CM)	TURB (FTU)	SUSP SOL (MG/L)	DISS O2 (MG/L)	O2 SAT (%)
RL 1	1225	-0.5	8.15	0.081	7.	36.	******[**]	******
RL 2	1325	0.0	8.15	0.113	8.	7.	12.58	87.31
RL 3	1425	1.5	8.30	0.104	8.	33.	12.84	92.93
RL 4	1520	1.0	8.40	0.106	6.	19.	12.64	90.22
RL 5	1622	1.5	8.45	0.116	6.	18.	12.11	87.65
RL 6	1720	1.0	8.50	0.118	6.	*****	12.84	91.65
RL 7	1830	1.0	8.55	0.105	7.	17.	******	******
RL 8	1930	1.0	8.45	0.104	10.	16.	12.48	89.00
RL 9	1950	0.8	8.35	0.099	6.	20.	12.65	89.79
RL 10	2130	0.3	8.25	0.099	7.	22.	12.44	87.07
RL 11	2230	0.4	8.20	0.098	6.	14.	12.29	86.26
RL 12	2330	0.2	7.90	0.075	8.	17.	12.40	86.55
RL 13	0030	0.2	7.85	0.073	12.	21.	12.48	87.10
RL 14	0130	0.5	7.85	0.100	7.	17.	12.56	88.41
RL 15	0230	0.5	7.95	0.106	10.	21.	12.75	89.74
RL 16	0330	0.5	7.85	0.109	7.	22.	13.07	92.00
RL 17	0430	0.5	7.65	0.101	12.	18.	10.74	75.60
RL 18	0530	0.5	7.70	0.112	8.	*****	******	******
RL 19	0630	0.2	8.35	0.103	12.	19.	12.25	85.50
RL 20	0730	0.2	8.30	0.103	10.	19.	12.21	85.22
RL 21	0830	0.2	8.40	0.103	10.	31.	12.06	84.17
RL 22	0930	0.2	8.35	0.094	10.	12.	12.32	85.99
RL 23	1030	0.6	8.30	0.099	10.	17.	12.30	86.82
RL 24	1130	0.6	8.40	0.090	11.	*****	12.31	86.89
RL 25	1230	1.0	8.05	0.083	11.	15.	12.32	87.94
RL 26	1330	0.7	8.00	0.110	10.	19.	12.53	88.69
RL 27	1430	0.4	8.00	0.126	18.	30.	12.44	87.32
RL 28	1530	0.4	7.90	0.111	15.	25.	12.27	86.12
RL 29	1630	0.6	7.85	0.116	14.	13.	12.23	86.33
RL 30	1730	0.4	7.85	0.108	12.	13.	12.36	86.75
RL 31	1830	0.7	7.75	0.117	13.	21.	12.38	87.63
RL 32	1930	0.5	7.75	0.112	15.	23.	11.01	77.50
RL 33	2030	0.5	7.70	0.116	12.	14.	10.63	74.82
RL 34	2130	0.5	7.75	0.111	11.	19.	******	******
RL 35	2230	0.5	7.65	0.112	11.	21.	11.84	83.34
RL 36	2330	0.4	7.65	0.103	10.	12.	11.68	81.98
RL 37	0030	0.7	7.75	0.093	11.	13.	12.11	85.72
RL 38	0130	1.0	7.75	0.111	15.	30.	12.31	87.87
RL 39	0230	1.0	7.75	0.108	15.	13.	12.44	88.79
RL 40	0330	1.0	7.75	0.112	14.	30.	12.32	87.94
RL 41	0430	1.8	7.75	0.110	13.	16.	12.11	88.37
RL 42	0530	1.1	7.75	0.111	10.	78.	11.97	85.60
RL 43	0630	0.6	7.75	0.115	10.	30.	12.13	85.62
RL 44	0730	0.6	7.85	0.107	11.	16.	12.09	85.34
RL 45	0830	0.5	7.90	0.113	9.	19.	12.35	86.93
RL 46	0930	0.4	7.95	0.109	10.	22.	12.20	85.63
RL 47	1030	0.4	8.00	0.101	10.	21.	12.23	85.84
RL 48	1130	0.5	7.90	0.101	12.	23.	12.40	87.28
RL 49	1235	0.6	7.90	0.091	12.	16.	12.46	87.95
RL 50	1330	0.6	7.85	0.090	12.	22.	******	******
RL 51	1430	1.7	8.00	0.109	27.	81.	******	******
RL 52	1530	1.7	7.95	0.113	25.	63.	******	******
RL 53	1630	1.7	7.95	0.113	22.	50.	******	******

* Station
RL = Reference marsh large channel

** ****** = No data

PARAMETERS

Temperature, pH, Conductivity, Turbidity, Suspended Solids, Dissolved Oxygen, and Percent Oxygen Saturation

Table B'71

Data for 54-hr Tidal Study in January 1977

STATION*	TIME	TEMP (C)	PH	COND (MMHO/CM)	TURB (FTU)	SUSP SOL (MG/L)	DISS O2 (MG/L)	O2 SAT (%)
RS 1	1250	0.0	8.15	0.097	7.	17.	******[**]	******
RS 2	1355	1.0	8.05	0.101	6.	15.	12.77	91.15
RS 3	1455	1.0	8.40	0.107	6.	19.	12.74	90.94
RS 4	1535	1.0	8.40	0.114	5.	23.	12.50	89.22
RS 5	1640	1.4	8.45	0.115	7.	19.	12.14	87.62
RS 6	1745	1.0	8.40	0.110	12.	44.	12.94	92.36
RS 7	1850	1.0	8.55	0.104	8.	*****	12.61	90.01
RS 8	1950	0.5	8.45	0.105	6.	22.	******	******
RS 9	2050	0.5	8.45	0.097	6.	22.	12.43	87.49
RS 10	2150	0.4	8.00	0.097	6.	19.	12.70	89.14
RS 11	2250	0.0	8.05	******	7.	29.	12.39	85.99
RS 12	2350	0.0	7.95	0.078	7.	20.	12.29	85.29
RS 13	0110	0.0	7.85	0.099	12.	11.	12.44	86.33
RS 14	0200	0.5	7.90	0.114	6.	*****	12.56	88.41
RS 15	0300	0.5	7.85	0.116	11.	14.	12.53	88.20
RS 16	0400	0.5	7.85	0.109	6.	120.	12.85	90.45
RS 17	0500	0.0	7.75	0.110	13.	15.	9.67	67.11
RS 18	0600	0.0	7.65	0.107	10.	116.	12.45	86.40
RS 19	0700	0.5	8.30	0.105	12.	15.	12.49	87.91
RS 20	0800	0.5	8.40	0.108	12.	13.	12.30	86.58
RS 21	0900	0.5	8.25	0.110	10.	*****	12.29	86.51
RS 22	1000	0.1	8.10	0.108	12.	11.	12.08	84.07
RS 23	1100	0.6	8.25	0.106	8.	11.	11.78	83.15
RS 24	1200	1.0	8.15	0.090	10.	20.	12.82	91.51
RS 25	1300	0.8	8.05	0.106	12.	29.	12.45	88.37
RS 26	1400	0.6	7.95	0.108	20.	39.	12.27	86.61
RS 27	1500	0.6	7.85	0.109	14.	17.	12.33	87.03
RS 28	1600	0.6	7.75	0.125	14.	23.	12.02	84.84
RS 29	1700	0.6	7.75	0.122	15.	27.	16.34	15.34
RS 30	1800	0.6	7.75	0.121	14.	25.	11.88	83.86
RS 31	1900	0.5	7.75	0.121	12.	18.	******	******
RS 32	2000	0.0	7.95	0.106	10.	15.	******	******
RS 33	2100	0.0	7.75	0.106	11.	13.	******	******
RS 34	2200	0.0	7.70	0.106	10.	*****	12.05	83.63
RS 35	2300	0.0	7.75	0.106	9.	19.	11.85	82.24
RS 36	0000	0.0	7.75	0.103	11.	14.	12.26	85.09
RS 37	0100	0.5	7.80	0.110	17.	16.	12.59	88.62
RS 38	0200	0.5	8.10	0.112	14.	34.	12.23	86.88
RS 39	0300	0.7	7.85	0.115	15.	17.	12.03	85.15
RS 40	0400	0.7	7.75	0.118	*****	27.	11.92	84.37
RS 41	0500	0.6	7.55	0.125	14.	21.	12.07	85.20
RS 42	0600	0.6	7.75	0.124	14.	16.	11.11	78.42
RS 43	0700	0.5	7.90	0.118	12.	35.	12.40	87.28
RS 44	0800	0.5	7.75	0.114	12.	14.	12.29	86.51
RS 45	0900	0.4	7.99	0.129	10.	25.	11.49	80.65
RS 46	1000	0.3	7.90	0.107	10.	18.	12.11	84.76
RS 47	1100	0.7	8.05	0.105	10.	41.	12.45	88.13
RS 48	1200	0.5	7.90	0.106	9.	13.	12.73	89.60
RS 49	1300	0.6	8.10	0.098	14.	21.	******	******
RS 50	1400	1.5	7.95	0.104	29.	82.	******	******
RS 51	1500	1.5	8.00	0.111	33.	72.	******	******
RS 52	1600	2.0	7.95	0.114	30.	60.	******	******
RS 53	1700	1.8	7.95	0.108	31.	49.	******	******

* Station
RS = Reference marsh small channel

** ****** = No data

PARAMETERS

Temperature, pH, Conductivity, Turbidity, Suspended Solids, Dissolved Oxygen, and Percent Oxygen Saturation

Table B'72

Data for 54-hr Tidal Study in January 1977

STATION*	TIME	ALK (MEQ/L)	CHL (UG/L)	PHAE (UG/L)	FOFA	VOL C (MG/L)	TOT C (MG/L)
AP 1	1340	1.11	1.07	2.59	1.29	2.0	12.5
AP 2	1426	0.67	0.77	1.55	1.33	1.7	7.5
AP 3	1526	0.63	0.89	1.92	1.32	1.5	6.9
AP 4	1534	0.59	0.71	1.04	1.41	2.8	6.3
AP 5	1815	0.41	0.59	0.74	1.44	3.2	14.8
AP 6	1935	0.50	0.49	0.78	1.39	3.2	8.1
AP 7	2035	0.35	0.67	0.85	1.44	4.0	4.9
AP 8	2120	0.55	1.19	2.85	1.29	3.9	8.3
AP 9	2230	0.33	2.55	5.72	1.31	3.2	15.3
AP 10	2330	0.50	1.01	2.30	1.30	3.1	8.9
AP 11	0015	********	0.73	1.80	1.28	2.6	7.5
AP 12	0107	0.43	0.66	1.55	1.30	2.0	8.8
AP 13	0212	0.01	0.67	0.74	1.48	1.8	10.5
AP 14	0315	0.51	0.70	0.62	1.53	1.5	8.4
AP 15	0415	0.63	0.67	0.58	1.54	1.4	12.5
AP 16	0625	0.62	0.54	0.60	1.47	2.0	12.8
AP 17	0730	0.68	0.51	0.56	1.47	4.5	9.1
AP 18	0825	0.89	0.54	0.58	1.48	3.5	10.9
AP 19	0920	0.67	0.62	1.28	1.33	2.8	14.2
AP 20	1025	0.26	0.59	1.26	1.32	2.5	13.5
AP 21	1145	0.74	0.59	1.00	1.37	5.1	12.1
AP 22	1215	0.62	0.59	0.75	1.44	******	******
AP 23	1315	0.50	0.86	0.63	1.58	******	******
AP 24	1420	0.36	0.86	0.99	1.47	1.2	12.8
AP 25	1511	0.49	1.00	1.04	1.49	1.5	9.5
AP 26	1620	0.43	0.71	0.81	1.47	1.4	7.3
AP 27	1730	0.38	******	******	******	1.5	8.5
AP 28	1815	0.50	0.81	1.14	1.42	2.0	7.8
AP 29	2030	0.43	0.86	0.93	1.48	1.0	5.7
AP 30	2230	0.39	1.32	1.99	1.40	0.8	6.3
AP 31	2345	0.34	1.08	1.95	1.36	0.9	7.1
AP 32	0025	0.33	0.66	0.92	1.42	1.3	5.1
AP 33	0135	0.27	******	******	1.44	1.2	5.5
AP 34	0230	0.35	0.71	0.90	1.51	1.5	9.8
AP 35	0325	0.25	0.71	0.67	1.46	1.0	7.2
AP 36	0440	0.22	0.75	0.89	1.50	1.2	7.5
AP 37	0555	0.37	0.75	0.74	1.49	2.0	8.9
AP 38	0705	0.61	0.80	0.82	1.64	1.5	10.7
AP 39	0900	0.56	0.70	0.38	******	1.4	7.1
AP 40	0945	0.54	******	******	******	1.3	7.0
AP 41	1000	0.47	******	******	1.46	2.2	10.8
AP 42	1130	0.49	2.02	2.42	1.42	2.5	9.4
AP 43	1215	0.40	3.16	4.25	1.40	2.4	7.4
AP 44	1315	0.57	7.46	3.61	1.48	3.1	13.5
AP 45	1415	0.56	2.36	2.58	1.36	2.8	12.2
AP 46	1515	0.55	2.33	4.12	1.36	2.4	11.4
AP 47	1617	0.57	4.31	7.63	1.30	2.0	15.5
AP 48	1715	0.56	6.55	14.94	******	1.8	14.3
AP 49	****	******	******	******	******	******	******
AP 50	****	******	******	******	******	******	******
AP 51	****	******	******	******	******	******	******
AP 52	****	******	******	******	******	******	******
AP 53	****	******	******	******	******	******	******

* Station
AP = Artificial Habitat Development Site pipe

** ****** = No data

PARAMETERS

Alkalinity, Chlorophyll, Phaeophytin, Fo/Fa Ratio, Volatile Dissolved Organic Carbon, Total Dissolved Organic Carbon

Table B'73

Data for 54-hr Tidal Study in January 1977

STATION*	TIME	ALK (MEQ/L)	CHL (UG/L)	PHAE (UG/L)	FOFA	VOL C (MG/L)	TOT C (MG/L)
AB 1	1310	0.78	0.92	1.52	1.38	2.1	8.1
AB 2	1415	0.68	0.92	1.26	1.42	2.4	12.3
AB 3	1512	0.45	0.73	0.84	1.46	1.9	15.8
AB 4	1623	0.59	0.59	0.47	1.56	********	******
AB 5	1750	0.50	0.49	0.60	1.44	1.5	9.2
AB 6	1910	0.34	0.56	0.67	1.46	2.5	8.5
AB 7	2020	0.42	0.58	1.04	1.36	2.4	7.3
AB 8	2110	******	******	******	******	1.9	9.4
AB 9	2215	******	******	******	******	******	******
AB 10	2335	******	******	******	******	******	******
AB 11	0005	0.53	******	******	******	******	******
AB 12	0100	******	******	******	******	******	******
AB 13	0212	******	******	******	******	******	******
AB 14	0302	0.40	0.67	0.60	1.53	2.2	5.4
AB 15	0405	0.63	0.66	0.59	1.53	4.0	6.2
AB 16	0606	0.69	0.55	0.41	1.57	1.9	4.5
AB 17	0709	0.70	0.52	0.51	1.51	2.4	5.9
AB 18	0809	0.60	0.55	0.69	1.44	2.9	6.7
AB 19	0906	******	******	******	******	******	******
AB 20	1000	******	******	******	******	******	******
AB 21	1130	******	******	******	******	******	******
AB 22	1212	******	******	******	******	******	******
AB 23	1310	0.61	1.51	2.46	1.38	3.1	5.7
AB 24	1400	0.33	0.95	0.97	1.49	2.1	3.8
AB 25	1500	0.44	0.86	0.99	1.47	1.2	4.4
AB 26	1600	0.44	0.67	0.70	1.49	1.0	5.9
AB 27	1715	0.40	0.78	0.73	1.52	0.9	7.2
AB 28	1800	0.40	0.80	0.78	1.50	1.5	8.5
AB 29	2000	0.34	0.97	1.07	1.48	2.2	8.2
AB 30	2210	******	******	******	******	******	******
AB 31	2330	******	******	******	******	******	******
AB 32	0013	******	******	******	******	******	******
AB 33	0105	0.36	0.62	0.70	1.47	1.1	7.4
AB 34	0210	0.30	0.79	0.99	1.47	1.2	6.5
AB 35	0310	0.25	0.73	0.90	1.44	2.1	6.2
AB 36	0415	0.31	******	******	******	1.0	5.8
AB 37	0530	0.30	0.84	0.80	1.51	1.5	4.3
AB 38	0650	0.51	0.77	0.75	1.50	2.5	4.2
AB 39	0730	0.58	******	******	******	2.8	10.5
AB 40	0835	0.61	******	******	******	2.2	11.7
AB 41	0930	0.57	0.75	0.66	1.53	2.1	12.9
AB 42	1120	******	******	******	******	******	******
AB 43	1200	******	******	******	******	******	******
AB 44	1300	******	******	******	******	******	******
AB 45	1400	0.56	1.72	2.80	1.37	1.4	15.9
AB 46	1500	0.51	1.78	2.25	1.44	1.8	16.7
AB 47	1600	0.60	1.40	2.33	1.39	2.5	14.2
AB 48	1700	0.44	3.02	6.33	1.32	2.4	14.0
AB 49	******	******	******	******	******	******	******
AB 50	****	******	******	******	******	******	******
AB 51	****	******	******	******	******	******	******
AB 52	****	******	******	******	******	******	******
AB 53	****	******	******	******	******	******	******

* Station
AB = Artificial Habitat Development Site breach

** ****** = No data

PARAMETERS

Alkalinity, Chlorophyll, Phaeophytin, Fo/Fa Ratio, Volatile Dissolved Organic Carbon, Total Dissolved Organic Carbon

Table B'74

Data for 54-hr Tidal Study in January 1977

STATION*	TIME	ALK (MEQ/L)	CHL (UG/L)	PHAE (UG/L)	FOFA	VOL C (MG/L)	TOT C (MG/L)
RL 1	1225	0.29	0.73	0.85	1.46	0.8	10.2
RL 2	1325	0.56	0.75	0.80	1.46	0.9	10.5
RL 3	1425	0.44	0.66	0.69	1.49	1.1	10.4
RL 4	1520	0.46	0.63	0.67	1.48	1.2	7.3
RL 5	1622	0.45	0.73	0.75	1.49	0.6	5.4
RL 6	1720	0.47	0.80	0.86	1.48	****** **	******
RL 7	1830	0.29	0.47	0.75	1.38	0.7	6.8
RL 8	1930	0.34	0.63	0.54	1.54	1.0	7.3
RL 9	1950	0.35	0.71	0.51	1.58	0.8	8.1
RL 10	2130	0.43	0.74	0.58	1.56	0.9	14.3
RL 11	2230	0.64	******	******	******	1.1	5.8
RL 12	2330	0.07	0.74	0.62	1.54	1.5	7.7
RL 13	0030	0.05	0.84	0.77	1.52	2.0	4.5
RL 14	0130	0.44	0.99	0.97	1.50	******	******
RL 15	0230	0.57	0.78	0.77	1.52	1.3	7.3
RL 16	0330	0.46	0.81	0.84	1.49	1.6	8.4
RL 17	0430	0.40	0.73	0.74	1.50	1.4	5.9
RL 18	0530	0.48	0.69	0.77	1.47	0.9	14.9
RL 19	0630	0.46	0.67	0.54	1.56	0.9	5.8
RL 20	0730	0.44	0.73	0.63	1.54	0.5	7.5
RL 21	0830	0.26	0.77	0.59	1.56	0.7	4.8
RL 22	0930	0.22	0.63	0.47	1.58	0.8	3.5
RL 23	1030	0.24	0.75	0.40	1.65	1.3	5.6
RL 24	1130	0.34	0.78	0.62	1.56	1.1	4.2
RL 25	1230	0.30	0.80	0.66	1.55	0.7	6.2
RL 26	1330	0.32	0.69	0.69	1.50	0.3	2.1
RL 27	1430	0.39	0.95	0.77	1.55	0.5	5.9
RL 28	1530	0.25	0.92	0.84	1.50	2.1	5.8
RL 29	1630	0.29	0.56	0.54	1.51	0.7	5.8
RL 30	1730	0.33	******	******	******	0.9	7.4
RL 31	1830	0.38	0.66	0.69	1.49	1.1	4.5
RL 32	1930	0.28	0.73	0.73	1.50	1.1	7.2
RL 33	2030	0.25	0.71	0.64	1.52	0.8	6.7
RL 34	2130	0.35	0.60	0.49	1.55	2.8	7.7
RL 35	2230	0.20	0.62	0.56	1.52	1.5	7.5
RL 36	2330	0.31	0.62	0.38	1.62	1.3	7.3
RL 37	0030	******	0.77	0.60	1.56	1.2	7.7
RL 38	0130	0.44	0.84	0.80	1.51	2.0	8.1
RL 39	0230	0.49	0.82	0.67	1.55	1.1	6.5
RL 40	0330	0.51	0.71	0.85	1.46	******	******
RL 41	0430	0.56	0.74	0.67	1.52	0.7	7.1
RL 42	0530	0.36	0.60	0.63	1.49	0.9	8.2
RL 43	0630	0.52	0.66	0.58	1.53	0.9	5.3
RL 44	0730	0.61	0.66	0.60	1.52	0.4	6.6
RL 45	0830	0.60	0.69	0.67	1.50	0.2	10.9
RL 46	0930	0.48	0.75	0.62	1.55	0.6	11.2
RL 47	1030	0.43	0.70	0.45	1.61	1.0	12.5
RL 48	1130	0.49	0.85	0.74	1.53	1.1	13.1
RL 49	1235	0.23	0.89	0.64	1.58	1.5	12.4
RL 50	1330	0.30	0.90	0.78	1.54	0.8	10.5
RL 51	1430	0.44	1.74	2.28	1.43	0.9	9.5
RL 52	1530	0.45	1.37	1.60	1.46	1.2	12.1
RL 53	1630	0.47	1.22	1.54	1.44	1.3	12.9

* Station
RL = Reference marsh large channel

** ****** = No data

PARAMETERS

Alkalinity, Chlorophyll, Phaeophytin, Fo/Fa Ratio, Volatile Dissolved Organic Carbon, Total Dissolved Organic Carbon

Table B'75

Data for 54-hr Tidal Study in January 1977

STATION*	TIME	ALK (MEG/L)	CHL (UG/L)	PHAE (UG/L)	FOFA	VOL C (MG/L)	TOT C (MG/L)
RS 1	1250	0.52	0.89	1.08	1.45	1.2	12.5
RS 2	1355	0.45	1.00	0.73	1.58	1.5	14.2
RS 3	1455	0.57	0.96	0.82	1.54	0.8	7.5
RS 4	1535	0.39	0.71	1.06	1.40	0.9	8.9
RS 5	1640	0.26	0.67	0.78	1.46	1.5	6.7
RS 6	1745	0.33	0.77	0.52	1.60	2.2	7.5
RS 7	1850	0.25	0.60	0.56	1.52	1.2	6.0
RS 8	1950	0.24	0.59	0.62	1.49	1.4	8.2
RS 9	2050	0.28	0.66	0.45	1.59	0.7	9.5
RS 10	2150	0.19	0.95	0.42	1.69	********	15.8
RS 11	2250	0.46	******	******	******	1.7	6.7
RS 12	2350	0.27	0.80	0.73	1.52	1.4	8.3
RS 13	0110	******	0.64	0.75	1.46	2.0	5.9
RS 14	0200	0.54	0.81	0.71	1.53	2.1	8.5
RS 15	0300	0.45	0.75	0.80	1.49	1.3	9.9
RS 16	0400	0.46	0.62	0.48	1.56	0.9	10.2
RS 17	0500	0.52	0.63	0.82	1.43	0.9	6.8
RS 18	0600	0.58	0.69	0.51	1.57	1.6	12.5
RS 19	0700	0.36	0.75	0.59	1.56	1.1	6.3
RS 20	0800	0.50	0.81	0.41	1.66	1.5	7.8
RS 21	0900	0.83	0.70	0.47	1.60	1.8	7.9
RS 22	1000	0.35	0.67	0.44	1.68	2.3	5.5
RS 23	1100	0.39	0.80	0.49	1.62	0.5	8.1
RS 24	1200	0.29	0.63	0.53	1.54	1.3	7.1
RS 25	1300	0.35	0.85	0.81	1.51	1.8	8.8
RS 26	1400	0.33	1.74	1.60	1.52	2.1	4.5
RS 27	1500	0.41	0.71	0.75	1.48	2.0	6.4
RS 28	1600	0.35	0.80	0.96	1.45	1.9	7.3
RS 29	1700	0.35	0.64	0.73	1.47	1.6	5.0
RS 30	1800	0.25	0.74	0.78	1.49	0.9	5.9
RS 31	1900	0.30	0.73	0.75	1.49	1.0	8.9
RS 32	2000	0.31	0.64	0.70	1.48	1.1	12.3
RS 33	2100	0.24	0.62	0.70	1.47	1.2	14.2
RS 34	2200	0.27	******	******	******	1.5	7.9
RS 35	2300	0.20	0.67	0.62	1.52	0.8	8.4
RS 36	0000	0.15	******	******	******	0.7	8.9
RS 37	0100	0.46	******	******	******	1.3	9.1
RS 38	0200	0.51	0.92	0.90	1.50	******	******
RS 39	0300	0.54	0.86	0.89	1.50	******	******
RS 40	0400	******	0.70	0.90	1.47	1.7	9.5
RS 41	0500	0.53	******	******	******	1.9	12.2
RS 42	0600	0.49	0.70	0.62	1.53	2.0	14.3
RS 43	0700	0.39	0.77	0.73	1.51	1.1	15.8
RS 44	0800	0.36	0.70	0.63	1.52	0.7	20.4
RS 45	0900	0.35	0.78	0.62	1.56	2.2	21.5
RS 46	1000	0.47	0.80	0.63	1.56	1.8	25.7
RS 47	1100	0.45	0.79	0.66	1.54	2.5	15.3
RS 48	1200	0.49	0.99	0.77	1.56	1.4	14.2
RS 49	1300	0.32	1.23	0.84	1.55	1.2	12.8
RS 50	1400	0.50	1.89	2.29	1.45	2.1	12.6
RS 51	1500	0.46	1.62	2.25	1.42	2.8	11.1
RS 52	1600	0.43	1.41	1.88	1.43	1.8	9.5
RS 53	1700	0.31	2.03	2.15	1.48	2.1	8.7

* Station
RS = Reference marsh small channel

** ****** = No data

PARAMETERS

Alkalinity, Chlorophyll, Phaeophytin, Fo/Fa Ratio, Volatile Dissolved Organic Carbon, Total Dissolved Organic Carbon

Table B'76

Data for 54-hr Tidal Study in January 1977

STATION*	HG (UG/L)	NH4 (MG/L)	NO2+NO3 (MG/L)	PO4 (MG/L)	TDN (MG/L)	TDP (MG/L)	TKN (MG/L)	TP (MG/L)
APA 1	0.220	0.36	2.03	0.039	2.72	0.282	3.45	0.183
APA 2	0.368	0.36	2.46	0.044	2.69	0.205	3.17	0.168
APA 3	0.240	0.36	2.42	0.037	2.54	0.131	3.38	0.220
APA 4	0.293	0.42	2.44	0.019	4.14	0.125	5.09	0.257
APA 5	0.256	0.54	2.29	0.012	3.50	0.120	6.28	0.211
APA 6	0.214	0.45	2.87	0.041	2.94	0.103	5.16	0.220
APA 7	********	******	******	******	******	******	******	******
APA 8	0.187	0.69	3.08	0.031	3.15	0.113	3.87	0.232
APA 9	0.329	0.50	1.96	0.034	2.54	0.289	4.38	0.197
APA 10	0.269	0.54	2.26	0.023	3.19	0.287	3.83	0.159
APA 11	0.309	0.49	1.76	0.041	2.76	0.295	3.96	0.188
APA 12	0.244	0.42	1.58	0.030	2.50	0.273	2.72	0.182
APA 13	0.195	0.41	1.96	0.044	2.04	0.279	2.08	0.195
APA 14	0.250	0.40	2.65	0.055	2.71	0.114	3.41	0.251
APA 15	0.436	0.45	1.12	0.031	2.61	0.126	3.21	0.219
APA 16	0.175	0.46	1.57	0.048	2.56	0.285	3.02	0.157
APA 17	0.272	0.36	1.13	0.046	1.24	0.279	1.45	0.161
APA 18	******	******	******	******	******	******	******	******
APA 19	0.253	0.87	1.23	0.057	2.68	0.281	3.27	0.179
APA 20	0.477	0.43	1.35	0.057	1.53	0.123	2.36	0.283
APA 21	0.509	0.48	1.08	0.070	1.67	0.114	2.26	0.308
APA 22	0.232	0.69	2.21	0.069	2.78	0.125	3.56	0.311
APB 1	0.210	0.38	1.64	0.048	3.11	0.299	3.29	0.179
APB 2	0.410	0.37	1.96	0.055	2.22	0.292	4.45	0.208
APB 3	0.220	0.37	1.70	0.044	2.21	0.285	6.42	0.264
APB 4	0.283	0.37	2.35	0.032	3.58	0.105	5.16	0.228
APB 5	0.250	0.57	2.42	0.035	3.43	0.107	4.86	0.269
APB 6	0.206	0.38	2.39	0.049	3.12	0.126	4.25	0.227
APB 7	******	******	******	******	******	******	******	******
APB 8	0.195	0.47	3.05	0.058	3.21	0.113	3.25	0.247
APB 9	0.345	0.54	2.61	0.023	4.08	0.278	6.16	0.199
APB 10	0.260	0.51	2.69	0.050	3.28	0.297	4.56	0.189
APB 11	0.296	0.45	2.68	0.066	2.70	0.298	2.98	0.192
APB 12	0.258	0.43	2.17	0.067	3.03	0.295	4.07	0.179
APB 13	0.233	0.36	2.35	0.058	2.43	0.293	2.87	0.185
APB 14	0.230	0.41	1.91	0.071	2.82	0.124	3.65	0.327
APB 15	0.421	0.51	1.86	0.049	2.49	0.106	2.58	0.253
APB 16	0.166	0.44	2.03	0.058	2.50	0.273	3.50	0.198
APB 17	0.255	0.46	1.94	0.082	2.05	0.093	2.30	0.185
APB 18	******	******	******	******	******	******	******	******
APB 19	0.234	0.85	1.99	0.062	2.69	0.289	3.38	0.208
APB 20	0.508	0.46	2.35	0.045	2.66	0.156	3.32	0.189
APB 21	0.426	0.47	1.60	0.043	2.71	0.145	3.43	0.323
APB 22	0.226	0.47	2.03	0.062	2.69	0.152	3.05	0.321

* Station
APA = Artificial Habitat Development Site pipe (alpha sample), APB = Artificial Habitat Development Site pipe (beta sample)

** ****** = No data

PARAMETERS

Dissolved Mercury, Dissolved Ammonium, Dissolved Nitrate plus Nitrite, Dissolved Orthophosphate, Total Dissolved Nitrogen, Total Dissolved Phosphorus, Total Kjeldahl Nitrogen (unfiltered sample), and Total Phosphorus (unfiltered sample)

Table B'77

Data for 54-hr Tidal Study in January 1977

STATION*	HG (UG/L)	NH4 (MG/L)	NO2+NO3 (MG/L)	PO4 (MG/L)	TDN (MG/L)	TDP (MG/L)	TKN (MG/L)	TP (MG/L)
ABA 1	0.291	0.41	1.64	0.032	2.69	0.110	3.38	0.225
ABA 2	0.436	0.57	1.70	0.036	1.72	0.126	1.94	0.249
ABA 3	0.218	0.42	1.79	0.022	2.43	0.117	2.86	0.239
ABA 4	********	******	******	******	******	******	******	******
ABA 5	******	******	******	******	******	******	******	******
ABA 6	0.469	0.44	1.67	0.056	2.01	0.141	1.83	0.251
ABA 7	******	******	******	******	******	******	******	******
ABA 8	1.307	0.40	1.56	0.045	2.49	0.109	3.18	0.219
ABA 9	******	******	******	******	******	******	******	******
ABA 10	******	******	******	******	******	******	******	******
ABA 11	0.239	0.41	2.18	0.033	2.45	0.117	2.68	0.266
ABA 12	0.340	0.32	2.42	0.051	2.53	0.122	2.63	0.235
ABA 13	0.210	0.43	2.07	0.032	2.48	0.129	2.74	0.254
ABA 14	******	******	******	******	******	******	******	******
ABA 15	******	******	******	******	******	******	******	******
ABA 16	0.257	0.56	1.75	0.053	2.43	0.139	4.06	0.271
ABA 17	******	******	******	******	******	******	******	******
ABA 18	0.250	0.50	1.45	0.043	2.17	0.139	3.42	0.262
ABA 19	******	******	******	******	******	******	******	******
ABA 20	******	******	******	******	******	******	******	******
ABA 21	******	******	******	******	******	******	******	******
ABA 22	0.260	0.40	1.44	0.045	1.61	0.135	1.72	0.283
ABB 1	0.300	0.42	1.26	0.041	2.63	0.112	3.81	0.249
ABB 2	0.403	0.60	1.64	0.023	2.06	0.125	2.56	0.294
ABB 3	0.208	0.42	2.25	0.032	2.47	0.113	2.79	0.211
ABB 4	******	******	******	******	******	******	******	******
ABB 5	******	******	******	******	******	******	******	******
ABB 6	0.494	0.40	2.32	0.029	2.63	0.126	3.07	0.296
ABB 7	******	******	******	******	******	******	******	******
ABB 8	1.372	0.53	2.22	0.035	2.58	0.122	2.76	0.239
ABB 9	******	******	******	******	******	******	******	******
ABB 10	******	******	******	******	******	******	******	******
ABB 11	0.231	0.43	2.19	0.031	2.24	0.112	2.27	0.277
ABB 12	0.193	0.37	1.02	0.050	1.07	0.107	2.74	0.245
ABB 13	0.220	0.38	1.69	0.039	2.55	0.125	3.12	0.259
ABB 14	******	******	******	******	******	******	******	******
ABB 15	******	******	******	******	******	******	******	******
ABB 16	0.270	0.46	1.69	0.051	2.63	0.124	3.31	0.274
ABB 17	******	******	******	******	******	******	******	******
ABB 18	0.240	0.41	1.61	0.043	1.99	0.120	1.90	0.278
ABB 19	******	******	******	******	******	******	******	******
ABB 20	******	******	******	******	******	******	******	******
ABB 21	******	******	******	******	******	******	******	******
ABB 22	0.242	0.54	1.46	0.047	1.04	0.130	1.89	0.283

* Station
ABA = Artificial Habitat Development Site breach (alpha sample), ABB = Artificial Habitat Development Site breach (beta sample)

** ****** = No data

PARAMETERS

Dissolved Mercury, Dissolved Ammonium, Dissolved Nitrate plus Nitrite, Dissolved Orthophosphate, Total Dissolved Nitrogen, Total Dissolved Phosphorus, Total Kjeldahl Nitrogen (unfiltered sample), and Total Phosphorus (unfiltered sample)

Table B'78

Data for 54-hr Tidal Study in January 1977

STATION*	HG (UG/L)	NH4 (MG/L)	NO2+NO3 (MG/L)	PO4 (MG/L)	TDN (MG/L)	TDP (MG/L)	TKN (MG/L)	TP (MG/L)
RLA 1	0.220	0.42	1.64	0.029	1.82	0.099	2.62	0.179
RLA 2	0.237	0.61	1.11	0.038	3.42	0.105	4.66	0.179
RLA 3	0.131	0.77	2.71	0.024	3.83	0.113	4.01	0.194
RLA 4	********	******	******	******	******	******	******	0.163
RLA 5	1.051	0.24	2.39	0.026	2.92	0.112	3.34	******
RLA 6	0.210	0.31	1.75	0.025	1.89	0.114	1.94	0.203
RLA 7	0.230	0.28	2.55	0.022	2.61	0.101	2.58	0.227
RLA 8	0.194	0.38	1.34	0.033	3.27	0.089	3.64	0.202
RLA 9	******	******	******	******	******	******	******	0.204
RLA 10	0.360	0.37	1.33	0.019	1.94	0.098	2.61	******
RLA 11	0.160	0.46	2.07	0.028	2.19	0.095	2.37	0.192
RLA 12	0.207	0.97	1.56	0.042	2.07	0.106	3.98	0.191
RLA 13	0.161	0.58	1.90	0.030	3.12	0.103	4.05	0.172
RLA 14	******	******	******	******	******	******	******	******
RLA 15	******	******	1.29	******	******	******	******	******
RLA 16	0.173	0.37	******	0.021	2.97	0.100	6.24	0.137
RLA 17	******	******	******	******	******	******	******	******
RLA 18	0.310	0.55	1.09	0.029	3.26	0.087	4.53	0.110
RLA 19	0.240	0.54	1.47	0.030	2.07	0.102	2.23	0.145
RLA 20	******	******	******	******	******	******	******	******
RLA 21	******	******	0.98	******	******	******	******	******
RLA 22	0.200	0.41	******	0.031	1.13	0.287	1.20	0.123
RLB 1	0.200	0.34	2.03	0.028	2.76	0.104	3.66	0.204
RLB 2	0.269	0.44	1.48	0.040	3.39	0.121	5.36	0.258
RLB 3	0.122	0.84	1.45	0.029	3.43	0.101	3.66	0.207
RLB 4	******	******	2.02	******	******	******	******	0.224
RLB 5	1.087	0.34	1.73	0.023	3.25	0.100	4.92	******
RLB 6	0.227	0.44	******	0.033	1.98	0.108	2.56	0.256
RLB 7	0.163	0.34	1.98	0.032	2.49	0.114	2.78	0.189
RLB 8	0.185	0.33	1.71	0.035	2.96	0.096	3.38	0.135
RLB 9	******	******	1.63	******	******	******	******	0.202
RLB 10	0.387	0.33	2.04	0.032	2.24	0.097	2.45	******
RLB 11	0.140	0.36	******	0.050	2.19	0.098	2.38	0.182
RLB 12	0.235	1.24	1.56	0.053	2.08	0.109	2.15	0.222
RLB 13	0.175	0.41	1.75	0.042	3.96	0.127	5.19	0.229
RLB 14	******	******	******	******	******	******	******	******
RLB 15	******	******	0.98	******	******	******	******	******
RLB 16	0.165	0.37	******	0.034	2.71	0.121	5.97	0.156
RLB 17	******	******	******	******	******	******	******	******
RLB 18	0.330	0.49	1.48	0.039	3.30	0.085	6.15	0.105
RLB 19	0.230	0.69	1.34	0.037	2.97	0.095	4.14	0.134
RLB 20	******	******	******	******	******	******	******	******
RLB 21	******	******	1.28	******	******	******	******	******
RLB 22	0.210	0.35	******	0.041	1.34	0.106	1.51	0.174

* Station
RLA = Reference marsh large channel (alpha sample), and RLB = Reference marsh large channel (beta sample)

** ****** = No data

PARAMETERS

Dissolved Mercury, Dissolved Ammonium, Dissolved Nitrate plus Nitrite, Dissolved Orthophosphate, Total Dissolved Nitrogen, Total Dissolved Phosphorus, Total Kjeldahl Nitrogen (unfiltered sample), and Total Phosphorus (unfiltered sample)

Table B'79

Data for 54-hr Tidal Study in January 1977

STATION*	HG (UG/L)	NH4 (MG/L)	NO2+NO3 (MG/L)	PO4 (MG/L)	TDN (MG/L)	TDP (MG/L)	TKN (MG/L)	TP (MG/L)
RSA 1	0.220	0.64	1.82	0.030	2.27	0.100	2.44	0.197
RSA 2	0.231	0.59	1.68	0.034	2.44	0.132	3.91	0.230
RSA 3	0.270	0.37	1.51	0.037	2.48	0.126	3.48	0.231
RSA 4	********	******	2.10	******	******	******	******	0.194
RSA 5	0.231	0.32	1.09	0.025	3.36	0.101	3.23	******
RSA 6	0.224	0.44	******	0.032	2.44	0.098	2.46	0.189
RSA 7	******	******	******	******	******	******	******	******
RSA 8	0.250	0.43	1.53	0.026	2.36	0.093	2.90	0.166
RSA 9	******	******	0.76	******	******	******	******	0.138
RSA 10	0.163	0.50	1.27	0.032	2.08	0.073	1.66	******
RSA 11	0.250	0.82	******	0.038	2.47	0.070	2.59	0.134
RSA 12	0.209	0.42	2.01	0.037	2.21	0.087	2.70	0.163
RSA 13	0.120	0.33	1.42	0.033	2.31	0.093	3.58	0.174
RSA 14	******	******	******	******	******	******	******	******
RSA 15	******	******	1.07	******	******	******	******	******
RSA 16	0.165	0.35	******	0.030	2.86	0.085	3.75	0.172
RSA 17	******	******	******	******	******	******	******	******
RSA 18	0.156	0.36	1.22	0.033	2.72	0.081	5.20	0.149
RSA 19	0.274	0.29	1.43	0.035	1.60	0.077	1.58	0.145
RSA 20	******	******	******	******	******	******	******	******
RSA 21	******	******	1.25	******	******	******	******	******
RSA 22	0.279	0.45	******	0.029	1.79	0.077	1.52	0.139
RSB 1	0.390	0.48	1.43	0.032	1.77	0.086	2.42	0.123
RSB 2	0.262	0.46	1.80	0.038	2.29	0.098	3.44	0.153
RSB 3	0.280	0.44	1.57	0.025	2.47	0.111	2.96	0.216
RSB 4	******	******	1.47	******	******	******	******	0.165
RSB 5	0.360	0.35	1.82	0.026	2.61	0.097	3.26	******
RSB 6	0.250	0.37	******	0.041	2.49	0.098	3.84	0.188
RSB 7	******	******	******	******	******	******	******	******
RSB 8	0.263	0.29	1.92	0.051	2.45	0.085	2.72	0.172
RSB 9	******	******	1.62	******	******	******	******	0.160
RSB 10	0.216	0.44	1.61	0.037	2.38	0.083	2.70	******
RSB 11	0.200	0.59	******	0.042	2.25	0.092	2.08	0.196
RSB 12	0.365	0.38	2.19	0.043	2.34	0.097	2.39	0.180
RSB 13	0.210	0.36	1.70	0.037	2.58	0.102	4.62	0.174
RSB 14	******	******	******	******	******	******	******	******
RSB 15	******	******	1.68	******	******	******	******	******
RSB 16	0.663	0.32	******	0.032	2.37	0.096	3.72	0.198
RSB 17	******	******	******	******	******	******	******	******
RSB 18	0.354	0.35	1.09	0.037	3.61	0.108	4.72	0.224
RSB 19	0.200	0.27	1.12	0.042	1.79	0.112	2.68	0.199
RSB 20	******	******	******	******	******	******	******	******
RSB 21	******	******	1.37	******	******	******	******	******
RSB 22	0.230	0.43	******	0.031	2.10	0.096	2.34	0.186

* Station
RSA = Reference marsh small channel (alpha sample), and RSB = Reference marsh small channel (beta sample)

** ****** = No data

PARAMETERS

Dissolved Mercury, Dissolved Ammonium, Dissolved Nitrate plus Nitrite, Dissolved Orthophosphate, Total Dissolved Nitrogen, Total Dissolved Phosphorus, Total Kjeldahl Nitrogen (unfiltered sample), and Total Phosphorus (unfiltered sample)

Table B'80

Data for 54-hr Tidal Study in January 1977

STATION*	TIME	DCA (MG/L)	DFE (MG/L)	DMN (MG/L)	DZN (MG/L)
APA 1	1340	15.1	0.46	0.046	0.109
APA 2	1426	14.5	0.37	0.047	0.132
APA 3	1526	14.7	0.72	0.049	0.093
APA 4	1534	14.7	0.17	0.032	0.033
APA 5	1815	11.9	0.07	0.028	0.096
APA 6	1935	12.6	0.11	0.061	0.165
APA 7	2035	13.9	0.57	0.126	0.066
APA 8	2120	16.5	0.45	0.338	0.035
APA 9	2230	16.8	2.74	0.344	0.133
APA 10	2330	17.6	0.16	0.390	0.124
APA 11	0015	18.5	0.43	0.325	0.032
APA 12	0107	18.3	0.24	0.349	0.122
APA 13	0212	11.2	0.11	0.036	0.165
APA 14	0315	12.9	0.20	0.244	0.104
APA 15	0415	14.5	0.10	0.037	0.088
APA 16	0625	13.1	0.30	0.039	0.074
APA 17	0730	16.0	0.09	0.269	0.054
APA 18	0825	17.4	0.08	0.082	0.045
APA 19	0920	17.7	0.40	0.132	0.051
APA 20	1025	18.4	0.94	0.279	0.073
APA 21	1145	17.0	0.35	0.116	0.086
APA 22	1215	16.7	0.39	0.111	0.104
APA 23	1315	12.5	0.23	0.053	0.081
APA 24	1420	14.3	0.14	0.029	0.046
APA 25	1511	14.2	0.30	0.033	0.038
APA 26	1620	14.1	0.09	0.028	0.082
APA 27	1730	13.9	0.27	0.031	0.078
APA 28	1815	13.5	0.24	0.031	0.049
APA 29	2030	12.8	0.10	0.032	0.117
APA 30	2230	14.4	0.29	0.074	0.027
APA 31	2345	12.6	0.78	0.102	0.207
APA 32	0025	13.4	0.09	0.032	0.100
APA 33	0135	13.9	0.12	0.019	0.058
APA 34	0230	13.9	0.39	0.027	0.063
APA 35	0325	13.1	0.30	0.019	0.035
APA 36	0440	14.0	0.30	0.229	0.110
APA 37	0555	13.1	0.24	0.027	0.077
APA 38	0705	13.8	0.30	0.039	0.165
APA 39	0800	14.1	0.41	0.035	0.141
APA 40	0845	12.9	0.08	0.025	0.043
APA 41	1000	10.7	0.17	0.032	0.051
APA 42	1130	12.6	0.06	0.042	0.074
APA 43	1215	12.1	0.40	0.050	0.061
APA 44	1315	13.4	0.10	0.027	******
APA 45	1415	14.4	0.23	0.029	0.071
APA 46	1515	14.5	0.14	0.032	0.078
APA 47	1617	11.6	0.11	0.029	0.142
APA 48	1715	14.2	0.05	0.033	0.060
APA 49	******	******	******	******	******
APA 50	****	******	******	******	******
APA 51	****	******	******	******	******
APA 52	****	******	******	******	******
APA 53	****	******	******	******	******

* Station
APA = Artificial Habitat Development Site pipe (alpha sample only)

** ****** = No data

PARAMETERS

Dissolved Calcium, Dissolved Iron, Dissolved Manganese, and Dissolved Zinc

Table B'81

Data for 54-hr Tidal Study in January 1977

STATION*	TIME	DCA (MG/L)	DFE (MG/L)	DMN (MG/L)	DZN (MG/L)
APB 1	1340	12.2	0.19	0.031	0.034
APB 2	1426	9.0	0.17	0.031	0.070
APB 3	1526	12.4	0.66	0.045	0.085
APB 4	1534	13.1	0.25	0.031	0.066
APB 5	1815	12.8	0.08	0.032	0.039
APB 6	1935	9.2	0.04	0.037	0.043
APB 7	2035	13.0	0.49	0.086	0.061
APB 8	2120	10.9	0.15	0.264	0.091
APB 9	2230	9.3	0.12	0.156	0.088
APB 10	2330	13.4	0.16	0.355	0.068
APB 11	0015	13.6	0.77	0.246	0.059
APB 12	0107	14.0	0.36	0.284	0.032
APB 13	0212	12.3	0.06	0.037	0.039
APB 14	0315	12.8	0.40	0.041	0.036
APB 15	0415	13.2	0.36	0.034	0.054
APB 16	0625	13.7	0.30	0.038	0.049
APB 17	0730	14.1	0.07	0.062	0.054
APB 18	0825	15.8	0.09	0.104	0.024
APB 19	0920	17.2	.13	0.126	0.029
APB 20	1025	16.8	0.11	0.235	0.049
APB 21	1145	15.4	0.14	0.109	0.036
APB 22	1215	10.8	0.36	0.074	0.074
APB 23	1315	****** **	******	******	******
APB 24	1420	13.1	0.07	0.027	0.054
APB 25	1511	11.0	0.37	0.027	0.275
APB 26	1620	12.4	0.28	0.022	0.051
APB 27	1730	13.0	0.40	0.029	0.046
APB 28	1815	13.0	0.21	0.066	0.059
APB 29	2030	12.0	0.14	0.029	0.041
APB 30	2230	13.2	0.81	0.091	0.064
APB 31	2345	12.0	0.59	0.094	0.049
APB 32	0025	7.8	0.13	0.020	0.049
APB 33	0135	11.4	0.08	0.015	0.036
APB 34	0230	11.8	0.29	0.029	0.107
APB 35	0325	11.8	0.32	0.024	0.056
APB 36	0440	11.6	0.22	0.020	0.043
APB 37	05[illegible]3	13.0	0.29	0.024	0.056
APB 38	0705	12.9	0.10	0.017	0.027
APB 39	0800	12.7	0.15	0.018	0.032
APB 40	0845	12.0	0.18	0.017	0.017
APB 41	1000	13.8	0.32	0.034	0.039
APB 42	1130	10.0	0.07	0.027	0.054
APB 43	1215	11.1	0.06	0.039	0.164
APB 44	1315	9.5	0.09	0.028	0.129
APB 45	1415	12.9	0.13	0.029	0.062
APB 46	1515	11.8	0.61	0.054	0.114
APB 47	1617	12.4	0.05	0.024	0.066
APB 48	1715	******	******	******	******
APB 49	****	******	******	******	******
APB 50	****	******	******	******	******
APB 51	****	******	******	******	******
APB 52	****	******	******	******	******
APB 53	****	******	******	******	******

* Station
APB = Artificial Habitat Development site pipe (beta sample only)

** ****** = No data

PARAMETERS

Dissolved Calcium, Dissolved Iron, Dissolved Manganese, and Dissolved Zinc

Table B'82

Data for 54-hr Tidal Study in January 1977

STATION*	TIME	DCA (MG/L)	DFE (MG/L)	DMN (MG/L)	DZN (MG/L)
ABA 1	1310	15.0	0.14	0.043	0.066
ABA 2	1415	14.9	0.42	0.045	0.027
ABA 3	1512	14.6	0.13	0.025	0.036
ABA 4	1623	14.4	0.07	0.020	0.024
ABA 5	1750	14.3	0.06	0.026	0.016
ABA 6	1910	13.8	0.04	0.045	0.021
ABA 7	2020	14.8	0.44	0.072	0.046
ABA 8	2110	********	******	******	******
ABA 9	2215	******	******	******	******
ABA 10	2335	******	******	******	******
ABA 11	0005	******	******	******	******
ABA 12	0100	******	******	******	******
ABA 13	0212	******	******	******	******
ABA 14	0302	14.8	0.34	0.045	0.028
ABA 15	0405	14.3	0.21	0.034	0.039
ABA 16	0606	14.4	0.14	0.036	0.035
ABA 17	0700	15.2	0.06	0.060	0.032
ABA 18	0800	16.3	0.21	0.066	0.029
ABA 19	0906	******	******	******	******
ABA 20	1000	******	******	******	******
ABA 21	1130	******	******	******	******
ABA 22	1212	******	******	******	******
ABA 23	1310	16.2	0.96	0.143	0.037
ABA 24	1400	14.4	0.18	0.028	0.018
ABA 25	1500	13.5	0.06	0.024	0.019
ABA 26	1600	14.1	0.16	0.031	0.112
ABA 27	1715	14.7	0.51	0.026	0.037
ABA 28	1800	14.5	0.59	0.037	0.050
ABA 29	2000	14.4	0.37	0.039	0.071
ABA 30	2210	******	******	******	******
ABA 31	2330	******	******	******	******
ABA 32	0013	******	******	******	******
ABA 33	0105	14.2	0.06	0.020	0.062
ABA 34	0210	14.1	0.07	0.021	0.028
ABA 35	0310	13.9	0.34	0.022	0.020
ABA 36	0415	13.7	0.17	0.034	0.140
ABA 37	0530	14.1	0.34	0.029	0.061
ABA 38	0650	12.9	0.38	0.024	0.019
ABA 39	0730	13.9	0.17	0.027	0.055
ABA 40	0835	12.1	0.35	0.032	0.064
ABA 41	0930	13.2	0.05	0.027	0.016
ABA 42	1120	******	******	******	******
ABA 43	1200	******	******	******	******
ABA 44	1300	******	******	******	******
ABA 45	1400	14.1	0.09	0.024	0.028
ABA 46	1500	14.4	0.16	0.031	0.076
ABA 47	1600	9.8	0.51	0.037	0.089
ABA 48	1700	******	******	******	******
ABA 49	****	******	******	******	******
ABA 50	****	******	******	******	******
ABA 51	****	******	******	******	******
ABA 52	****	******	******	******	******
ABA 53	****	******	******	******	******

* Station
ABA = Artificial Habitat Development Site breach (alpha sample only)

** ****** = No data

PARAMETERS

Dissolved Calcium, Dissolved Iron, Dissolved Manganese, and Dissolved Zinc

Table B'83

Data for 54-hr Tidal Study in January 1977

STATION*	TIME	DCA (MG/L)	DFE (MG/L)	DMN (MG/L)	DZN (MG/L)
ABB 1	1310	12.7	0.08	0.035	0.089
ABB 2	1415	15.3	0.20	0.046	0.054
ABB 3	1512	11.4	0.45	0.031	0.145
ABB 4	1623	13.4	0.09	0.020	0.074
ABB 5	1750	10.6	0.06	0.020	0.092
ABB 6	1910	14.2	0.32	0.050	0.043
ABB 7	2020	14.8	0.51	0.001	0.152
ABB 8	2110	********	******	******	******
ABB 9	2215	******	******	******	******
ABB 10	2335	******	******	******	******
ABB 11	0005	******	******	******	******
ABB 12	0100	******	******	******	******
ABB 13	0212	******	******	******	******
ABB 14	0302	******	0.44	0.038	0.047
ABB 15	0405	14.1	0.26	0.036	0.067
ABB 16	0606	14.6	0.25	0.042	0.100
ABB 17	0700	14.0	0.12	0.060	0.037
ABB 18	0800	15.8	0.32	0.063	0.069
ABB 19	0906	15.4	******	******	******
ABB 20	1000	******	******	******	******
ABB 21	1130	******	******	******	******
ABB 22	1212	******	******	******	******
ABB 23	1310	******	0.56	0.000	0.004
ABB 24	1400	14.4	0.34	0.033	0.051
ABB 25	1500	14.4	0.15	0.029	0.038
ABB 26	1600	14.7	0.10	0.016	0.114
ABB 27	1715	10.8	0.51	0.031	0.082
ABB 28	1800	13.7	0.10	0.025	0.035
ABB 29	2000	14.4	0.51	0.049	0.062
ABB 30	2210	14.2	******	******	******
ABB 31	2330	******	******	******	******
ABB 32	0013	******	******	******	******
ABB 33	0125	******	0.08	0.026	0.064
ABB 34	0210	14.3	0.09	0.025	0.085
ABB 35	0310	12.8	0.50	0.030	0.055
ABB 36	0415	13.2	0.07	0.018	0.073
ABB 37	0530	11.3	0.08	0.016	0.094
ABB 38	0650	9.2	0.35	0.026	0.099
ABB 39	0730	9.1	0.24	0.030	0.082
ABB 40	0835	13.6	0.27	0.026	0.091
ABB 41	0930	13.1	0.22	0.030	0.062
ABB 42	1120	13.1	******	******	******
ABB 43	1200	******	******	******	******
ABB 44	1300	******	******	******	******
ABB 45	1400	******	0.22	0.020	0.074
ABB 46	1500	10.4	0.32	0.035	0.107
ABB 47	1600	11.6	0.21	0.029	0.041
ABB 48	1700	14.6	1.17	0.056	0.052
ABB 49	****	******	******	******	******
ABB 50	****	******	******	******	******
ABB 51	****	******	******	******	******
ABB 52	****	******	******	******	******
ABB 53	****	******	******	******	******

* Station
ABB = Artificial Habitat Development Site breach (beta sample only)

** ****** = No data

PARAMETERS

Dissolved Calcium, Dissolved Iron, Dissolved Manganese, and Dissolved Zinc

Table B'84

Data for 54-hr Tidal Study in January 1977

STATION*	TIME	DCA (MG/L)	DFE (MG/L)	DMN (MG/L)	DZN (MG/L)
RLA 1	1225	10.2	0.34	0.042	0.177
RLA 2	1325	10.4	0.26	0.026	0.117
RLA 3	1425	11.0	0.42	0.030	0.086
RLA 4	1520	11.8	0.29	0.025	0.106
RLA 5	1622	13.1	0.37	0.016	0.022
RLA 6	1720	9.2	0.07	0.015	0.067
RLA 7	1830	9.4	0.43	0.024	0.082
RLA 8	1930	10.7	0.16	0.014	0.052
RLA 9	1950	12.1	0.25	0.040	0.071
RLA 10	2130	12.3	0.32	0.034	0.075
RLA 11	2230	11.2	0.50	0.045	0.099
RLA 12	2330	9.2	0.22	0.047	0.100
RLA 13	0030	8.2	0.25	0.037	0.052
RLA 14	0130	10.1	0.07	0.033	0.078
RLA 15	0230	12.3	0.15	0.019	0.109
RLA 16	0330	11.0	0.24	0.022	0.100
RLA 17	0430	12.0	0.32	0.027	0.024
RLA 18	0530	7.1	0.25	0.019	0.104
RLA 19	0630	12.9	0.40	0.027	0.015
RLA 20	0730	13.3	0.31	0.034	0.091
RLA 21	0830	10.0	0.34	0.054	0.070
RLA 22	0930	10.8	0.20	0.039	0.123
RLA 23	1030	10.0	0.39	0.040	0.057
RLA 24	1130	11.1	0.41	0.036	0.063
RLA 25	1230	11.1	0.20	0.035	0.101
RLA 26	1330	13.6	0.22	0.024	0.058
RLA 27	1430	13.3	0.33	0.036	0.066
RLA 28	1530	12.7	0.14	0.030	0.149
RLA 29	1630	10.0	0.37	0.024	0.063
RLA 30	1730	9.0	0.42	0.026	0.074
RLA 31	1830	9.4	0.40	0.023	0.066
RLA 32	1930	9.4	0.33	0.025	0.075
RLA 33	2030	11.7	0.46	0.025	0.068
RLA 34	2130	9.8	0.36	0.024	0.073
RLA 35	2230	12.3	0.29	0.026	0.030
RLA 36	2330	12.1	0.31	0.037	0.033
RLA 37	0030	11.3	0.23	0.031	0.074
RLA 38	0130	13.2	0.15	0.022	0.073
RLA 39	0230	11.0	0.52	0.031	0.079
RLA 40	0330	9.0	0.24	0.019	0.079
RLA 41	0430	13.7	0.20	0.030	0.131
RLA 42	0530	10.5	0.09	0.024	0.061
RLA 43	0630	11.7	0.20	0.020	0.055
RLA 44	0730	10.2	0.30	0.031	0.110
RLA 45	0830	10.1	0.20	0.023	0.070
RLA 46	0930	12.3	0.30	0.032	0.047
RLA 47	1030	7.5	0.10	0.027	0.134
RLA 48	1130	12.1	0.36	0.040	0.121
RLA 49	1235	11.5	0.16	0.036	0.061
RLA 50	1330	7.0	0.20	0.029	0.070
RLA 51	1430	9.1	0.10	0.018	0.107
RLA 52	1530	12.3	0.14	0.021	0.114
RLA 53	1630	13.2	0.40	0.033	0.027

* Station
RLA = Reference marsh large channel (alpha sample only)

PARAMETERS

Dissolved Calcium, Dissolved Iron, Dissolved Manganese, and Dissolved Zinc

Table B'85

Data for 54-hr Tidal Study in January 1977

STATION*	TIME	DCA (MG/L)	DFE (MG/L)	DMN (MG/L)	DZN (MG/L)
RLB 1	1225	11.1	0.30	0.041	0.065
RLB 2	1325	11.2	0.21	0.012	0.046
RLB 3	1425	11.2	0.26	0.024	0.036
RLB 4	1520	********	******	******	******
RLB 5	1622	11.3	0.26	0.017	0.049
RLB 6	1720	12.8	0.18	0.021	0.064
RLB 7	1830	12.3	0.19	0.017	0.019
RLB 8	1930	4.0	0.15	0.022	0.035
RLB 9	1950	11.9	0.44	0.030	0.018
RLB 10	2130	12.5	0.16	0.030	0.014
RLB 11	2230	12.0	0.28	0.042	0.054
RLB 12	2330	10.0	0.34	0.042	0.076
RLB 13	0030	10.6	0.59	0.047	0.043
RLB 14	0130	12.4	0.32	0.032	0.046
RLB 15	0230	13.0	0.43	0.030	0.048
RLB 16	0330	13.1	0.40	0.023	0.035
RLB 17	0430	12.5	0.13	0.020	0.029
RLB 18	0530	12.4	0.18	0.018	0.056
RLB 19	0630	12.3	0.10	0.021	0.025
RLB 20	0730	12.2	0.22	0.022	0.035
RLB 21	0830	12.2	0.13	0.035	0.039
RLB 22	0930	12.2	0.42	0.056	0.062
RLB 23	1030	12.3	0.31	0.046	0.046
RLB 24	1130	12.4	0.39	0.036	0.026
RLB 25	1230	11.3	0.13	0.036	0.042
RLB 26	1330	11.6	0.32	0.026	0.042
RLB 27	1430	12.5	0.31	0.027	0.031
RLB 28	1530	12.6	0.47	0.030	0.039
RLB 29	1630	12.6	0.14	0.028	0.048
RLB 30	1730	12.3	0.29	0.026	0.042
RLB 31	1830	12.4	0.52	0.030	0.035
RLB 32	1930	12.5	0.37	0.027	0.015
RLB 33	2030	12.5	0.36	0.029	0.027
RLB 34	2130	12.3	0.28	0.023	0.034
RLB 35	2230	12.4	0.30	0.038	0.075
RLB 36	2330	12.2	0.43	0.042	0.096
RLB 37	0030	11.5	0.25	0.030	0.035
RLB 38	0130	12.7	0.27	0.019	0.024
RLB 39	0230	12.3	0.56	0.040	0.052
RLB 40	0330	12.4	0.24	0.025	0.048
RLB 41	0430	12.7	0.29	0.019	0.038
RLB 42	0530	11.7	0.12	0.021	0.051
RLB 43	0630	11.4	0.36	0.020	0.018
RLB 44	0730	12.2	0.29	0.027	0.052
RLB 45	0830	10.8	0.21	0.020	0.038
RLB 46	0930	9.3	0.23	0.021	0.056
RLB 47	1030	11.4	0.18	0.026	0.042
RLB 48	1130	11.3	0.30	0.026	0.039
RLB 49	1235	11.2	0.28	0.038	0.064
RLB 50	1330	9.9	0.25	0.040	0.055
RLB 51	1430	12.6	0.38	0.027	0.060
RLB 52	1530	12.7	0.39	0.029	0.061
RLB 53	1630	******	******	******	******

* Station
RLB = Reference marsh large channel (beta sample only)

** ****** = No data

PARAMETERS

Dissolved Calcium, Dissolved Iron, Dissolved Manganese, and Dissolved Zinc

Table B'86

Data for 54-hr Tidal Study in January 1977

STATION*	TIME	DCA (MG/L)	DFE (MG/L)	DMN (MG/L)	DZN (MG/L)
RSA 1	1250	10.2	0.37	0.026	0.026
RSA 2	1355	12.3	0.20	0.020	0.027
RSA 3	1455	12.0	0.41	0.025	0.016
RSA 4	1535	12.2	0.21	0.018	0.038
RSA 5	1640	12.7	0.66	0.033	0.048
RSA 6	1745	12.3	0.09	0.016	0.031
RSA 7	1850	11.2	0.34	0.023	0.011
RSA 8	1950	12.4	0.24	0.028	0.039
RSA 9	2050	10.6	0.26	0.036	0.059
RSA 10	2150	10.8	0.39	0.042	0.014
RSA 11	2250	11.2	0.31	0.043	0.034
RSA 12	2350	9.8	0.42	0.048	0.046
RSA 13	0110	9.4	0.30	0.020	0.019
RSA 14	0200	12.9	0.14	0.023	0.057
RSA 15	0300	12.2	0.18	0.021	0.027
RSA 16	0400	12.0	0.21	0.020	0.049
RSA 17	0500	12.5	0.15	0.019	0.022
RSA 18	0600	10.2	0.29	0.021	0.042
RSA 19	0700	12.0	0.30	0.027	0.024
RSA 20	0800	13.0	0.19	0.031	0.038
RSA 21	0900	12.8	0.28	0.046	0.031
RSA 22	1000	12.4	0.18	0.049	0.024
RSA 23	1100	13.0	0.28	0.063	0.033
RSA 24	1200	11.2	0.47	0.043	0.057
RSA 25	1300	12.0	0.19	0.021	0.017
RSA 26	1400	12.1	0.55	0.039	0.030
RSA 27	1500	12.5	0.24	0.029	0.024
RSA 28	1600	12.6	0.49	0.031	0.024
RSA 29	1700	13.1	0.56	0.032	0.039
RSA 30	1800	12.9	0.48	0.027	0.018
RSA 31	1900	********	******	******	******
RSA 32	2000	12.0	0.18	0.021	0.023
RSA 33	2100	12.1	0.40	0.032	0.035
RSA 34	2200	12.2	0.38	0.031	0.020
RSA 35	2300	12.2	0.28	0.028	0.017
RSA 36	0000	11.0	0.38	0.031	0.045
RSA 37	0100	12.7	0.34	0.022	0.020
RSA 38	0200	12.4	0.48	0.031	0.059
RSA 39	0300	12.4	0.36	0.022	0.025
RSA 40	0400	12.6	0.10	0.017	0.046
RSA 41	0500	12.6	0.40	0.021	0.033
RSA 42	0600	12.7	0.24	0.018	0.040
RSA 43	0700	12.1	0.35	0.022	0.030
RSA 44	0800	11.3	0.38	0.027	0.062
RSA 45	0900	11.8	0.30	0.026	0.073
RSA 46	1000	10.9	0.24	0.022	0.040
RSA 47	1100	11.8	0.25	0.029	0.061
RSA 48	1200	11.5	0.28	0.022	0.032
RSA 49	1300	3.6	0.15	0.024	0.036
RSA 50	1400	11.4	0.35	0.028	0.032
RSA 51	1500	11.7	0.60	0.035	0.039
RSA 52	1600	13.0	******	0.023	0.088
RSA 53	1700	11.7	******	******	0.034

* Station
RSA = Reference marsh small channel (alpha sample only)

** ****** = No data

PARAMETERS

Dissolved Calcium, Dissolved Iron, Dissolved Manganese, and Dissolved Zinc

Table B'87

Data for 54-hr Tidal Study in January 1977

STATION*	TIME	DCA (MG/L)	DFE (MG/L)	DMN (MG/L)	DZN (MG/L)
RSB 1	1250	10.3	0.26	0.024	0.020
RSB 2	1355	11.8	0.24	0.027	0.017
RSB 3	1455	11.9	0.19	0.020	0.054
RSB 4	1535	12.1	0.18	0.020	0.041
RSB 5	1640	13.0	0.39	0.024	0.083
RSB 6	1745	11.5	0.24	0.020	0.017
RSB 7	1850	11.2	0.43	0.035	0.062
RSB 8	1950	12.3	0.30	0.024	0.015
RSB 9	2050	11.0	0.29	0.042	0.042
RSB 10	2150	12.0	0.41	0.048	0.031
RSB 11	2250	********	******	******	******
RSB 12	2350	10.0	0.50	0.047	0.022
RSB 13	0110	12.4	0.22	0.025	0.011
RSB 14	0200	12.6	0.16	0.027	0.050
RSB 15	0300	12.4	0.19	0.021	0.009
RSB 16	0400	12.4	0.14	0.016	0.013
RSB 17	0500	12.9	0.20	0.025	0.016
RSB 18	0600	12.7	0.10	0.027	0.021
RSB 19	0700	12.3	0.29	0.033	0.062
RSB 20	0800	13.0	0.37	0.056	0.030
RSB 21	0900	12.8	0.16	0.040	0.011
RSB 22	1000	12.9	0.36	0.047	0.013
RSB 23	1100	12.6	0.28	0.052	0.033
RSB 24	1200	11.6	0.12	0.030	0.016
RSB 25	1300	12.6	0.26	0.026	0.027
RSB 26	1400	12.5	0.31	0.026	0.010
RSB 27	1500	10.7	0.28	0.026	0.036
RSB 28	1600	13.2	0.56	0.032	0.027
RSB 29	1700	12.9	0.31	0.024	0.021
RSB 30	1800	12.8	0.44	0.024	0.013
RSB 31	1900	12.5	0.33	0.028	0.042
RSB 32	2000	12.6	0.43	0.033	0.015
RSB 33	2100	12.8	0.29	0.032	0.024
RSB 34	2200	******	******	******	******
RSB 35	2300	12.3	0.27	0.030	0.009
RSB 36	0000	11.5	0.43	0.029	0.018
RSB 37	0100	12.8	0.25	0.025	0.022
RSB 38	0200	13.1	0.18	0.024	0.056
RSB 39	0300	12.5	0.57	0.030	0.016
RSB 40	0400	11.4	0.07	0.012	0.006
RSB 41	0500	10.8	0.19	0.020	0.041
RSB 42	0600	13.0	0.07	0.017	0.017
RSB 43	0700	11.7	0.30	0.033	0.074
RSB 44	0800	10.8	0.23	0.020	0.050
RSB 45	0900	******	******	******	0.022
RSB 46	1000	11.2	0.46	0.029	0.041
RSB 47	1100	9.8	0.34	0.025	0.041
RSB 48	1200	12.0	0.20	0.039	0.068
RSB 49	1300	11.4	0.49	0.044	0.059
RSB 50	1400	10.2	0.31	0.034	0.061
RSB 51	1500	11.5	0.38	0.025	0.019
RSB 52	1600	******	******	******	0.008
RSB 53	1700	12.4	0.68	0.040	0.052

* Station
RSB = Reference marsh small channel (beta sample only)

** ****** = No data

PARAMETERS

Dissolved Calcium, Dissolved Iron, Dissolved Manganese, and Dissolved Zinc

Table B'88

Data for 54-hr Tidal Study in January 1977

PARTICULATE METALS----JANUARY 1975
(UG/G)

*STA/TIDE**		CA	CD	CU	FE	MN	NI	PB	ZN
AP	LS	4250	4.3	61.3	43220	844	73	91	291
AP	F-1†	3700	2.8	68.9	36540	838	49	73	266
AP	F-2†	3010	2.0	52.5	27735	686	50	54	226
AP	HS	4520	<5.0††	64.7	39390	623	90	71	304
AP	E	2700	<1.3	15.9	27460	435	56	68	147
AP	PWD	2920	1.5	30.2	24860	596	34	50	174
AB	F	1960	0.8	17.9	18940	468	28	39	122
AB	HS	5360	<11.5	110.	38580	672	190	100	384
AB	PPE	5000	<8.5	57.4	45690	716	150	120	343
AB	E	3870	2.7	55.1	36040	628	76	77	234
RL	LS	3950	13.0	54.2	42180	494	230	100	395
RL	F-1†	3870	6.2	26.7	38160	895	74	78	229
RL	F-2†	3850	1.6	15.6	36910	870	69	79	172
RL	HS	3820	<5.4	20.4	38750	695	87	58	152
RL	PPE	4570	<6.3	7.7	45910	823	120	140	194
RL	E	2770	5.6	15.2	27870	415	77	62	137
RS	LS	3770	<7.0	88.0	47140	409	140	100	311
RS	F	2320	2.2	ND‡	23790	556	49	53	107
RS	HS	3980	<9.4	27.0	47980	728	160	140	264
RS	PPE	4440	<8.4	62.9	37660	796	170	89	229
RS	E	2620	5.7	216.	28400	414	150	64	328

* Station
AP = Artificial Habitat Development Site Pipe, AB = Artificial Habitat Development Site Breach, RL = Reference marsh large channel, and RS = Reference marsh small channel

** Tide
LS = Low Slack Water, F = Flood, HS = High Slack Water, E = Ebb, PWD = Pore Water Drainage (end of ebb tide at AP only), and PPE = Preprecipitational Ebb at AB, RL, and RS only

† -1, -2 = duplicates

†† Below detection limit for specific metal and total amount of suspended solids for composited filter pads

‡ Not enough sample for detection

APPENDIX C'

TABLES C'1-C'115

STATISTICS

Table C'1

Statistics for Sediment Water at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			SEDIMENT WATER (%)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	56.8	65.1	19.4	84.5	16.8	35
Art	All	All	47.0	45.6	19.4	65.0	14.9	17
Ref	All	All	66.1	44.2	40.3	84.5	12.8	18
Art	High (AH)	All	32.3	25.5	19.8	45.3	11.3	5
"	"	Surface	44.2	2.2	43.1	45.3	1.6	2
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	24.4	7.6	19.8	27.4	4.0	3
Art	Inter-tidal (AI)	All	56.6	14.8	50.2	65.0	5.4	6
"	"	Surface	60.8	7.2	57.8	65.0	3.7	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	52.3	3.1	50.2	53.3	1.8	3
Art	Sub-tidal (AS)	All	49.6	43.8	19.4	63.2	15.7	6
"	"	Surface	59.2	7.5	55.7	63.2	3.8	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	40.1	33.9	19.4	53.3	18.1	3
Ref	High (RH)	All	74.8	18.0	66.5	84.5	7.3	6
"	"	Surface	81.0	7.3	77.2	84.5	3.7	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	68.7	4.8	66.5	71.3	2.4	3
Ref	Inter-tidal (RI)	All	51.7	22.1	40.3	62.4	7.4	6
"	"	Surface	52.7	6.8	48.9	55.7	3.5	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	50.8	22.1	40.3	62.4	11.1	3
Ref	Sub-tidal (RS)	All	71.8	22.4	58.3	80.7	8.5	6
"	"	Surface	77.4	7.6	73.1	80.7	3.9	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	66.2	17.1	58.3	75.4	8.6	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'2

Statistics for Sediment Water at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

SEDIMENT WATER (%)								
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	56.0	64.0	18.7	82.7	16.4	36
Art	All	All	44.2	41.8	18.7	60.5	11.8	18
Ref	All	All	67.9	34.0	48.7	82.7	10.7	18
Art	High (AH)	All	31.5	24.5	18.7	43.2	9.3	6
"	"	Surface	37.3	15.7	27.5	43.2	8.5	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	25.7	12.7	18.7	31.4	6.5	3
Art	Inter-tidal (AI)	All	52.2	15.8	43.9	59.7	6.5	6
"	"	Surface	57.9	3.4	56.3	59.7	1.7	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	46.5	5.0	43.9	48.9	2.5	3
Art	Sub-tidal (AS)	All	48.9	19.0	41.5	60.5	7.1	6
"	"	Surface	52.7	17.0	43.5	60.5	8.6	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	45.1	6.3	41.5	47.8	3.2	3
Ref	High (RH)	All	68.6	25.6	57.1	82.7	11.9	6
"	"	Surface	79.2	6.7	76.0	82.7	3.4	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	57.9	1.8	57.1	58.9	0.9	3
Ref	Inter-tidal (RI)	All	61.4	24.9	48.7	73.6	10.6	6
"	"	Surface	69.3	10.5	63.1	73.6	5.5	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	53.6	14.3	48.7	63.0	8.2	3
Ref	Sub-tidal (RS)	All	73.7	17.0	65.6	82.6	6.5	6
"	"	Surface	79.2	5.2	77.4	82.6	2.9	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	68.1	4.6	65.6	70.2	2.3	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'3

Statistics for Sediment Volatile Solids at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			SEDIMENT VOLATILE SOLIDS (%)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	11.3	27.5	0.6	28.1	6.4	35
Art	All	All	7.2	11.0	0.6	11.6	3.4	17
Ref	All	All	15.1	19.8	8.3	28.1	6.3	18
Art	High (AH)	All	5.2	11.0	0.6	11.6	4.8	5
"	"	Surface	10.2	2.8	8.8	11.6	2.0	2
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	1.8	2.9	0.6	3.5	1.5	3
Art	Inter-tidal (AI)	All	8.3	1.7	7.7	9.4	0.7	6
"	"	Surface	7.9	0.4	7.7	8.1	0.2	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	8.8	1.5	7.9	9.4	0.8	3
Art	Sub-tidal (AS)	All	7.8	10.0	1.1	11.1	3.5	6
"	"	Surface	9.0	1.3	8.2	9.5	0.7	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	6.7	10.0	1.1	11.1	5.1	3
Ref	High (RH)	All	19.6	16.4	10.6	27.0	6.1	6
"	"	Surface	21.0	16.4	10.6	27.0	9.0	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	18.1	4.1	15.4	19.5	2.3	3
Ref	Inter-tidal (RI)	All	10.6	6.4	8.3	14.7	2.2	6
"	"	Surface	10.0	2.8	8.3	11.1	1.5	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	11.2	5.7	9.0	14.7	3.0	3
Ref	Sub-tidal (RS)	All	15.2	18.0	10.1	28.1	6.7	6
"	"	Surface	11.0	1.8	10.1	11.9	0.9	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	19.3	14.3	13.8	28.1	7.7	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'4

Statistics for Sediment Volatile Solids at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

SEDIMENT VOLATILE SOLIDS (%)								
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	12.2	32.3	0.7	33.0	6.6	36
Art	All	All	7.8	11.1	0.7	11.8	3.1	18
Ref	All	All	16.6	23.1	9.9	33.0	6.3	18
Art	High (AH)	All	4.4	9.0	0.7	9.7	3.1	6
"	"	Surface	6.7	4.8	4.9	9.7	2.6	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	2.2	2.4	0.7	3.1	1.3	3
Art	Inter-tidal (AI)	All	9.2	3.3	7.5	10.8	1.1	6
"	"	Surface	9.3	0.6	9.1	9.7	0.3	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	9.1	3.3	7.5	10.8	1.6	3
Art	Sub-tidal (AS)	All	9.8	3.5	8.3	11.8	1.3	6
"	"	Surface	10.5	2.7	9.1	11.8	1.4	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	9.0	1.3	8.3	9.6	0.7	3
Ref	High (RH)	All	20.8	21.2	11.8	33.0	9.5	6
"	"	Surface	29.1	8.2	24.8	33.0	4.1	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	12.5	1.9	11.8	13.7	1.0	3
Ref	Inter-tidal (RI)	All	13.5	5.1	9.9	15.0	1.9	6
"	"	Surface	14.5	1.2	13.8	15.0	0.6	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	12.5	4.9	9.9	14.8	2.5	3
Ref	Sub-tidal (RS)	All	15.5	6.8	12.8	19.6	2.8	6
"	"	Surface	14.1	0.4	13.8	14.2	0.2	3
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	17.0	6.8	12.8	19.6	3.6	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'5

Statistics for Sediment Temperature at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

SEDIMENT TEMPERATURE (°C)

Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
EEE	All	All	23.7	6.8	20.5	27.3	1.9	36
AEE	All	All	23.1	5.2	20.5	25.7	1.5	18
REE	All	All	24.3	6.3	21.0	27.0	2.0	18
AHE	High (AH)	All	23.3	2.1	22.4	24.5	0.9	6
AHS	"	Surface	24.0	1.3	23.2	24.5	0.7	3
AHM	"	Mid-depth	--††	--	--	--	--	--
AHD	"	Deep	22.6	0.4	22.4	22.8	0.2	3
AIE	Inter-tidal (AI)	All	22.4	3.6	20.5	24.1	1.6	6
AIS	"	Surface	23.8	0.6	23.5	24.1	0.3	3
AIM	"	Mid-depth	--††	--	--	--	--	--
AID	"	Deep	21.0	0.9	20.5	21.4	0.4	3
ASE	Sub-tidal (AS)	All	23.7	4.6	21.1	25.7	1.8	6
ASS	"	Surface	25.3	0.7	25.0	25.7	0.4	3
ASM	"	Mid-depth	--††	--	--	--	--	--
ASD	"	Deep	22.1	1.6	21.1	22.7	0.9	3
RHE	High (RH)	All	23.0	2.6	21.6	24.2	1.1	6
RHS	"	Surface	24.1	0.3	23.9	24.2	0.2	3
RHM	"	Mid-depth	--††	--	--	--	--	--
RHD	"	Deep	22.0	0.7	21.6	22.3	0.4	3
RIE	Inter-tidal (RI)	All	26.4	2.3	25.0	27.3	1.0	6
RIS	"	Surface	27.3	0.0	27.3	27.3	0.0	3
RIM	"	Mid-depth	--††	--	--	--	--	--
RID	"	Deep	25.6	1.0	25.0	26.0	0.5	3
RSE	Sub-tidal (RS)	All	23.5	4.2	21.0	25.2	1.9	6
RSS	"	Surface	25.2	0.0	25.2	25.2	0.0	3
RSM	"	Mid-depth	--††	--	--	--	--	--
RSD	"	Deep	21.8	1.3	21.0	22.3	0.7	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† Temperature measured at the top and bottom of each core in the field immediately after collection.

Table C'6

Statistics for Sediment Temperature at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

SEDIMENT TEMPERATURE (°C)

Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
EEE	All	All	-0.3	11.0	-8.0	3.0	3.0	36
AEE	All	All	-1.2	11.0	-8.0	3.0	3.9	18
REE	All	All	0.5	4.0	-1.0	3.0	1.3	18
AHE	High (AH)	All	-6.0	4.0	-8.0	-4.0	2.2	6
AHS	"	Surface	-8.0	0.0	-8.0	-8.0	0.0	3
AHM	"	Mid-depth	--	--	--	--	--	--
AHD	"	Deep	-4.0	0.0	-4.0	-4.0	0.0	3
AIE	Inter-tidal (AI)	All	2.5	1.0	2.0	3.0	0.5	6
AIS	"	Surface	2.0	0.0	2.0	2.0	0.0	3
AIM	"	Mid-depth	--	--	--	--	--	--
AID	"	Deep	3.0	0.0	3.0	3.0	0.0	3
ASE	Sub-tidal (AS)	All	0.0	0.0	0.0	0.0	0.0	6
ASS	"	Surface	0.0	0.0	0.0	0.0	0.0	3
ASM	"	Mid-depth	--	--	--	--	--	--
ASD	"	Deep	0.0	0.0	0.0	0.0	0.0	3
RHE	High (RH)	All	0.8	1.5	0.0	1.5	0.8	6
RHS	"	Surface	1.5	0.0	1.5	1.5	0.0	3
RHM	"	Mid-depth	--	--	--	--	--	--
RHD	"	Deep	0.0	0.0	0.0	0.0	0.0	3
RIE	Inter-tidal (RI)	All	0.7	4.0	-1.0	3.0	1.9	6
RIS	"	Surface	2.3	1.0	2.0	3.0	0.6	3
RIM	"	Mid-depth	--	--	--	--	--	--
RID	"	Deep	-1.0	0.0	-1.0	-1.0	0.0	3
RSE	Sub-tidal (RS)	All	0.1	2.5	-1.0	1.5	1.2	6
RSS	"	Surface	1.2	0.5	1.0	1.5	0.3	3
RSM	"	Mid-depth	--	--	--	--	--	--
RSM	"	Deep	-1.0	0.0	-1.0	-1.0	0.0	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

Table C'7

Statistics for Sediment pH at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			SEDIMENT pH					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	6.41	2.43	5.47	7.90	0.47	50
Art	All	All	6.61	1.78	6.12	7.90	0.35	26
Ref	All	All	6.19	1.58	5.47	7.05	0.49	24
Art	High (AH)	All	6.54	0.71	6.12	6.83	0.26	8
"	"	Surface	6.50	0.71	6.12	6.83	0.36	3
"	"	Mid-depth	6.44	0.43	6.22	6.65	0.30	2
"	"	Deep	6.65	0.30	6.50	6.80	0.15	3
Art	Inter-tidal (AI)	All	6.53	0.74	6.12	6.86	0.20	9
"	"	Surface	6.54	0.74	6.12	6.86	0.38	3
"	"	Mid-depth	6.57	0.08	6.54	6.62	0.05	3
"	"	Deep	6.47	0.19	6.37	6.56	0.10	3
Art	Sub-tidal (AS)	All	6.75	1.60	6.30	7.90	0.49	9
"	"	Surface	6.54	0.61	6.30	6.91	0.32	3
"	"	Mid-depth	6.61	0.29	6.46	6.75	0.14	3
"	"	Deep	7.09	1.50	6.40	7.90	0.76	3
Ref	High (RH)	All	5.82	1.21	5.47	6.68	0.39	9
"	"	Surface	6.19	0.93	5.75	6.68	0.47	3
"	"	Mid-depth	5.62	0.28	5.47	5.75	0.14	3
"	"	Deep	5.64	0.39	5.51	5.90	0.22	3
Ref	Inter-tidal (RI)	All	6.11	1.27	5.63	6.90	0.47	6
"	"	Surface	6.10	1.27	5.63	6.90	0.70	3
"	"	Mid-depth	6.06	0.51	5.81	6.32	0.36	2
"	"	Deep	6.24	0.00	6.24	6.24	0.00	1
Ref	Sub-tidal (RS)	All	6.61	0.75	6.30	7.05	0.22	9
"	"	Surface	6.70	0.53	6.52	7.05	0.30	3
"	"	Mid-depth	6.68	0.14	6.59	6.73	0.08	3
"	"	Deep	6.45	0.35	6.30	6.65	0.18	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

Table C'8

Statistics for Sediment pH at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

			SEDIMENT pH					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	6.47	2.08	5.27	7.35	0.51	49
Art	All	All	6.73	1.38	5.76	7.14	0.31	23
Ref	All	All	6.24	2.08	5.27	7.35	0.55	26
Art	High (AH)	All	6.41	1.34	5.76	7.10	0.49	5
"	"	Surface	6.41	1.34	5.76	7.10	0.67	3
"	"	Mid-depth	6.40	0.33	6.24	6.57	0.23	2
"	"	Deep	--††	--††	--††	--††	--††	--††
Art	Inter-tidal (AI)	All	6.81	0.51	6.52	7.03	0.20	9
"	"	Surface	6.84	0.33	6.63	6.96	0.18	3
"	"	Mid-depth	6.91	0.32	6.71	7.03	0.17	3
"	"	Deep	6.68	0.44	6.52	6.96	0.24	3
Art	Sub-tidal (AS)	All	6.82	0.60	6.54	7.14	0.17	9
"	"	Surface	6.89	0.44	6.70	7.14	0.22	3
"	"	Mid-depth	6.75	0.34	6.54	6.88	0.18	3
"	"	Deep	6.82	0.24	6.71	6.95	0.12	3
Ref	High (RH)	All	5.89	0.54	5.69	6.23	0.20	9
"	"	Surface	5.98	0.54	5.69	6.23	0.27	3
"	"	Mid-depth	5.89	0.43	5.69	6.12	0.22	3
"	"	Deep	5.78	0.08	5.75	5.83	0.04	3
Ref	Inter-tidal (RI)	All	6.79	1.20	6.15	7.35	0.48	8
"	"	Surface	6.87	1.02	6.33	7.35	0.51	3
"	"	Mid-depth	6.74	0.99	6.15	7.14	0.52	3
"	"	Deep	6.76	0.99	6.26	7.25	0.70	2
Ref	Sub-tidal (RS)	All	6.12	1.51	5.27	6.78	0.49	9
"	"	Surface	6.50	0.52	6.26	6.78	0.26	3
"	"	Mid-depth	6.01	0.91	5.53	6.44	0.46	3
"	"	Deep	5.84	1.11	5.27	6.38	0.56	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'9

Statistics for Sediment Redox Potential at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			SEDIMENT Eh (mV)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	116	448	8	456	79	51
Art	All	All	105	448	8	456	100	25
Ref	All	All	128	208	51	259	53	26
Art	High (AH)	All	182	448	8	456	168	7
"	"	Surface	414	84	372	456	59	2
"	"	Mid-depth	136	90	91	181	64	2
"	"	Deep	57	74	8	82	43	3
Art	Inter-tidal (AI)	All	62	46	42	88	15	9
"	"	Surface	64	43	45	88	22	3
"	"	Mid-depth	63	25	54	79	14	3
"	"	Deep	59	30	42	72	16	3
Art	Sub-tidal (AS)	All	88	83	45	128	27	9
"	"	Surface	102	40	86	126	21	3
"	"	Mid-depth	73	16	64	80	8	3
"	"	Deep	88	83	45	128	42	3
Ref	High (RH)	All	162	39	140	179	13	9
"	"	Surface	151	24	140	164	12	3
"	"	Mid-depth	166	23	153	176	12	3
"	"	Deep	169	19	160	179	10	3
Ref	Inter-tidal (RI)	All	157	148	111	259	51	8
"	"	Surface	209	101	158	259	50	3
"	"	Mid-depth	129	16	120	136	8	3
"	"	Deep	122	21	111	132	15	2
Ref	Sub-tidal (RS)	All	67	29	51	80	10	9
"	"	Surface	62	21	51	72	10	3
"	"	Mid-depth	67	23	52	75	13	3
"	"	Deep	73	14	66	80	7	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

Table C'10

Statistics for Sediment Redox Potential at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

			SEDIMENT Eh (mV)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	150	446	53	499	88	49
Art	All	All	124	446	53	499	117	23
Ref	All	All	173	173	75	248	43	26
Art	High (AH)	All	274	384	115	499	194	5
"	"	Surface	366	372	127	499	207	3
"	"	Mid-depth	136	41	115	156	29	2
"	"	Deep	--††	--††	--††	--††	--††	--††
Art	Inter-tidal (AI)	All	73	36	53	89	13	9
"	"	Surface	71	29	53	82	16	3
"	"	Mid-depth	76	26	61	87	14	3
"	"	Deep	71	28	61	89	15	3
Art	Sub-tidal (AS)	All	92	51	71	122	18	9
"	"	Surface	88	15	82	97	8	3
"	"	Mid-depth	76	13	71	84	7.2	3
"	"	Deep	112	22	100	122	11	3
Ref	High (RH)	All	192	77	159	236	20	9
"	"	Surface	180	35	159	194	18	3
"	"	Mid-depth	204	57	179	236	29	3
"	"	Deep	191	13	184	197	7	3
Ref	Inter-tidal (RI)	All	152	173	75	248	53	8
"	"	Surface	161	147	101	248	77	3
"	"	Mid-depth	142	104	75	179	58	3
"	"	Deep	153	20	143	163	14	2
Ref	Sub-tidal (RS)	All	173	120	96	216	45	9
"	"	Surface	150	89	96	185	47	3
"	"	Mid-depth	159	92	98	190	53	3
"	"	Deep	210	16	200	216	9	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'11

Statistics for Interstitial Water Dissolved Orthophosphate at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			DISSOLVED ORTHOPHOSPHATE (mg/l)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	0.079	0.086	0.042	0.128	0.025	37
Art	All	All	0.100	0.065	0.063	0.128	0.020	18
Ref	All	All	0.059	0.029	0.042	0.071	0.010	19
Art	High (AH)	All	0.112	0.009	0.109	0.117	0.006	2
"	"	Surface	0.117	0.000	0.117	0.117	0.000	1
"	"	Mid-depth	---††	---††	---††	---††	---††	--††
"	"	Deep	0.108	0.000	0.108	0.108	0.000	1
Art	Inter-tidal (AI)	All	0.100	0.061	0.066	0.128	0.022	8
"	"	Surface	0.121	0.021	0.107	0.128	0.012	3
"	"	Mid-depth	0.098	0.012	0.092	0.104	0.006	3
"	"	Deep	0.071	0.008	0.067	0.075	0.006	2
Art	Sub-tidal (AS)	All	0.096	0.062	0.063	0.125	0.019	8
"	"	Surface	0.109	0.012	0.103	0.115	0.008	2
"	"	Mid-depth	0.105	0.042	0.083	0.125	0.021	3
"	"	Deep	0.080	0.029	0.063	0.092	0.015	3
Ref	High (RH)	All	0.050	0.025	0.042	0.067	0.009	6
"	"	Surface	0.045	0.006	0.042	0.048	0.004	2
"	"	Mid-depth	0.055	0.019	0.048	0.067	0.011	3
"	"	Deep	0.047	0.000	0.047	0.047	0.000	1
Ref	Inter-tidal (RI)	All	0.054	0.005	0.051	0.056	0.002	4
"	"	Surface	0.054	0.005	0.051	0.056	0.003	3
"	"	Mid-depth	0.056	0.000	0.056	0.056	0.000	1
"	"	Deep	---††	---††	---††	---††	---††	--††
Ref	Sub-tidal (RS)	All	0.067	0.008	0.063	0.071	0.003	9
"	"	Surface	0.067	0.008	0.063	0.071	0.004	3
"	"	Mid-depth	0.067	0.005	0.065	0.070	0.003	3
"	"	Deep	0.068	0.007	0.064	0.071	0.004	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C' 12

Statistics for Interstitial Water Dissolved Orthophosphate at the James River Artificial Habitat Development Site and a Natural Reference

January 1977

			DISSOLVED ORTHOPHOSPHATE (mg/l)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	0.079	0.052	0.056	0.108	0.013	43
Art	All	All	0.076	0.052	0.056	0.108	0.012	19
Ref	All	All	0.082	0.046	0.056	0.102	0.013	24
Art	High (AH)	All	0.090	0.036	0.072	0.108	0.025	2
"	"	Surface	0.072	0.000	0.072	0.072	0.000	1
"	"	Mid-depth	0.108	0.000	0.108	0.108	0.000	1
"	"	Deep	---††	---††	---††	---††	---††	--††
Art	Inter-tidal (AI)	All	0.071	0.037	0.056	0.093	0.011	9
"	"	Surface	0.078	0.026	0.066	0.093	0.014	3
"	"	Mid-depth	0.067	0.023	0.056	0.079	0.012	3
"	"	Deep	0.070	0.016	0.061	0.078	0.008	3
Art	Sub-tidal (AS)	All	0.078	0.027	0.067	0.094	0.009	8
"	"	Surface	0.081	0.008	0.077	0.085	0.006	2
"	"	Mid-depth	0.078	0.027	0.067	0.094	0.014	3
"	"	Deep	0.075	0.010	0.072	0.082	0.006	3
Ref	High (RH)	All	0.073	0.024	0.056	0.080	0.008	8
"	"	Surface	0.007	0.000	0.077	0.077	0.000	2
"	"	Mid-depth	0.075	0.013	0.067	0.080	0.007	3
"	"	Deep	0.068	0.019	0.056	0.075	0.011	3
Ref	Inter-tidal (RI)	All	0.086	0.024	0.076	0.100	0.009	8
"	"	Surface	0.083	0.018	0.076	0.094	0.010	3
"	"	Mid-depth	0.093	0.014	0.086	0.100	0.007	3
"	"	Deep	0.079	0.007	0.076	0.083	0.005	2
Ref	Sub-tidal (RS)	All	0.087	0.039	0.063	0.102	0.016	8
"	"	Surface	0.078	0.030	0.063	0.093	0.021	2
"	"	Mid-depth	0.088	0.034	0.067	0.101	0.019	3
"	"	Deep	0.091	0.030	0.072	0.102	0.016	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'13

Statistics for Interstitial Water Total Dissolved Phosphorus at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			TOTAL DISSOLVED PHOSPHORUS (mg/l)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	0.160	0.288	0.090	0.378	0.072	39
Art	All	All	0.136	0.181	0.090	0.271	0.047	18
Ref	All	All	0.180	0.282	0.096	0.378	0.084	21
Art	High (AH)	All	0.128	0.014	0.119	0.133	0.009	3
"	"	Surface	0.133	0.000	0.133	0.133	0.000	1
"	"	Mid-depth	---††	---††	---††	---††	---††	--††
"	"	Deep	0.126	0.014	0.119	0.133	0.010	2
Art	Inter-tidal (AI)	All	0.141	0.139	0.096	0.235	0.050	6
"	"	Surface	0.108	0.000	0.108	0.108	0.000	1
"	"	Mid-depth	0.150	0.139	0.096	0.235	0.075	3
"	"	Deep	0.146	0.020	0.136	0.156	0.014	2
Art	Sub-tidal (AS)	All	0.136	0.181	0.090	0.271	0.056	9
"	"	Surface	0.123	0.021	0.112	0.133	0.011	3
"	"	Mid-depth	0.124	0.080	0.090	0.170	0.041	3
"	"	Deep	0.161	0.175	0.096	0.271	0.096	3
Ref	High (RH)	All	0.114	0.027	0.096	0.123	0.009	7
"	"	Surface	0.111	0.027	0.096	0.123	0.014	3
"	"	Mid-depth	0.115	0.012	0.110	0.122	0.006	3
"	"	Deep	0.115	0.000	0.115	0.115	0.000	1
Ref	Inter-tidal (RI)	All	0.210	0.269	0.101	0.370	0.114	5
"	"	Surface	0.253	0.269	0.101	0.370	0.138	3
"	"	Mid-depth	0.145	0.028	0.131	0.159	0.020	2
"	"	Deep	---††	---††	---††	---††	---††	--††
Ref	Sub-tidal (RS)	All	0.215	0.247	0.131	0.378	0.072	9
"	"	Surface	0.173	0.099	0.131	0.230	0.051	3
"	"	Mid-depth	0.196	0.069	0.168	0.237	0.036	3
"	"	Deep	0.276	0.165	0.213	0.378	0.089	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'14

Statistics for Interstitial Water Total Dissolved Phosphorus at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

TOTAL DISSOLVED PHORPHORUS (mg/l)

Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	0.153	0.134	0.098	0.232	0.028	39
Art	All	All	0.139	0.088	0.098	0.186	0.024	17
Ref	All	All	0.164	0.109	0.123	0.232	0.027	22
Art	High (AH)	All	0.107	0.000	0.107	0.107	0.000	1
"	"	Surface	0.107	0.000	0.107	0.107	0.000	1
"	"	Mid-depth	---††	---††	---††	---††	---††	--††
"	"	Deep	---††	---††	---††	---††	---††	--††
Art	Inter-tidal (AI)	All	0.137	0.088	0.098	0.186	0.028	9
"	"	Surface	0.120	0.046	0.098	0.144	0.023	3
"	"	Mid-depth	0.160	0.058	0.128	0.186	0.029	3
"	"	Deep	0.130	0.038	0.109	0.147	0.019	3
Art	Sub-tidal (AS)	All	0.147	0.047	0.125	0.172	0.018	7
"	"	Surface	0.168	0.000	0.168	0.168	0.000	1
"	"	Mid-depth	0.134	0.022	0.125	0.147	0.011	3
"	"	Deep	0.152	0.034	0.138	0.172	0.018	3
Ref	High (RH)	All	0.160	0.040	0.146	0.186	0.014	6
"	"	Surface	0.158	0.000	0.158	0.158	0.000	1
"	"	Mid-depth	0.151	0.014	0.146	0.160	0.008	3
"	"	Deep	0.174	0.025	0.161	0.186	0.018	2
Ref	Inter-tidal (RI)	All	0.187	0.081	0.151	0.232	0.027	8
"	"	Surface	0.172	0.030	0.159	0.189	0.016	3
"	"	Mid-depth	0.198	0.081	0.151	0.232	0.042	3
"	"	Deep	0.193	0.017	0.184	0.201	0.012	2
Ref	Sub-tidal (RS)	All	0.144	0.042	0.123	0.165	0.013	8
"	"	Surface	0.149	0.032	0.133	0.165	0.023	2
"	"	Mid-depth	0.143	0.017	0.134	0.151	0.009	3
"	"	Deep	0.141	0.029	0.123	0.152	0.016	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'15

Statistics for Sediment Bulk Total Phosphorus at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

BULK TOTAL PHOSPHORUS (μg/g)

Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	708	1540	65	1610	359	52
Art	All	All	746	1020	237	1260	311	27
Ref	All	All	666	1540	65	1610	407	25
Art	High (AH)	All	563	1020	237	1260	328	9
"	"	Surface	348	229	270	499	131	3
"	"	Mid-depth	515	580	237	817	291	3
"	"	Deep	827	751	500	1260	388	3
Art	Inter-tidal (AI)	All	800	915	295	1210	276	9
"	"	Surface	754	915	295	1210	458	3
"	"	Mid-depth	832	140	772	912	72	3
"	"	Deep	814	565	489	1054	292	3
Art	Sub-tidal (AS)	All	876	879	301	1180	268	9
"	"	Surface	912	96	862	958	48	3
"	"	Mid-depth	1030	338	792	1180	209	3
"	"	Deep	685	769	301	1070	385	3
Ref	High (RH)	All	338	551	65	616	197	9
"	"	Surface	409	423	193	616	212	3
"	"	Mid-depth	447	257	298	555	133	3
"	"	Deep	158	250	65	315	137	3
Ref	Inter-tidal (RI)	All	566	275	416	691	110	7
"	"	Surface	555	275	416	691	138	3
"	"	Mid-depth	574	221	463	684	156	2
"	"	Deep	576	139	507	646	98	2
Ref	Sub-tidal (RS)	All	1070	1380	234	1610	367	9
"	"	Surface	1160	254	996	1250	144	3
"	"	Mid-depth	1080	193	967	1160	99	3
"	"	Deep	975	1380	234	1610	694	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

Table C'16

Statistics for Sediment Bulk Total Phosphorus at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

BULK TOTAL PHOSPHORUS (μg/g)

Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	668	1470	199	1670	372	49
Art	All	All	690	1060	243	1300	328	24
Ref	All	All	648	1470	199	1670	416	25
Art	High (AH)	All	402	363	280	643	137	6
"	"	Surface	450	363	280	643	182	3
"	"	Mid-depth	355	166	280	446	84	3
"	"	Deep	--††	---††	--††	--††	--††	--††
Art	Inter-tidal (AI)	All	780	867	243	1110	299	9
"	"	Surface	1070	123	987	1110	71	3
"	"	Mid-depth	553	732	243	975	378	3
"	"	Deep	719	85	689	774	48	3
Art	Sub-tidal (AS)	All	791	1040	261	1300	355	9
"	"	Surface	907	773	527	1300	387	3
"	"	Mid-depth	578	879	261	1140	488	3
"	"	Deep	887	220	743	963	125	3
Ref	High (RH)	All	692	1380	222	1600	411	9
"	"	Surface	587	568	222	790	316	3
"	"	Mid-depth	622	498	323	821	263	3
"	"	Deep	869	1280	315	1600	660	3
Ref	Inter-tidal (RI)	All	545	921	199	1120	411	8
"	"	Surface	723	849	211	1060	451	3
"	"	Mid-depth	590	921	199	1120	476	3
"	"	Deep	212	19	203	222	13	2
Ref	Sub-tidal (RS)	All	701	1440	230	1670	461	8
"	"	Surface	1270	795	875	1670	562	2
"	"	Mid-depth	481	560	230	790	284	3
"	"	Deep	540	513	280	793	256	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'17

Statistics for Interstitial Water Dissolved Ammonium at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

DISSOLVED AMMONIUM (mg/l)

Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	2.09	5.93	0.34	6.27	1.63	38
Art	All	All	2.65	5.69	0.58	6.27	1.89	18
Ref	All	All	1.59	3.58	0.34	3.92	1.21	20
Art	High (AH)	All	1.14	1.32	0.58	1.90	0.68	3
"	"	Surface	--††	--††	--††	--††	--††	--††
"	"	Mid-depth	0.58	0.00	0.58	0.58	0.00	1
"	"	Deep	1.42	0.96	0.94	1.90	0.68	2
Art	Inter-tidal (AI)	All	3.14	5.64	0.63	6.27	2.16	6
"	"	Surface	1.71	0.00	1.71	1.71	0.00	1
"	"	Mid-depth	3.29	5.64	0.63	6.27	2.83	3
"	"	Deep	3.62	3.05	2.09	5.14	2.16	2
Art	Sub-tidal (AS)	All	2.83	5.19	0.68	5.87	1.86	9
"	"	Surface	0.84	0.36	0.68	1.04	0.18	3
"	"	Mid-depth	2.86	2.08	1.76	3.84	1.04	3
"	"	Deep	4.78	2.12	3.75	5.87	1.06	3
Ref	High (RH)	All	0.76	1.09	0.42	1.51	0.39	6
"	"	Surface	1.11	0.80	0.71	1.51	0.57	2
"	"	Mid-depth	0.64	0.26	0.51	0.77	0.13	3
"	"	Deep	0.42	0.00	0.42	0.42	0.00	1
Ref	Inter-tidal (RI)	All	0.64	0.86	0.34	1.20	0.35	5
"	"	Surface	0.54	0.38	0.34	0.72	0.19	3
"	"	Mid-depth	0.78	0.84	0.36	1.20	0.59	2
"	"	Deep	--††	--††	--††	--††	--††	--††
Ref	Sub-tidal (RS)	All	2.67	2.64	1.28	3.92	0.95	9
"	"	Surface	1.76	1.21	1.28	2.49	0.64	3
"	"	Mid-depth	2.79	0.83	1.79	3.62	0.93	3
"	"	Deep	3.46	0.80	3.12	3.92	0.41	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'18

Statistics for Interstitial Water Dissolved Ammonium at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

			DISSOLVED AMMONIUM (mg/l)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	2.31	4.45	1.11	5.56	1.08	43
Art	All	All	2.96	4.14	1.42	5.56	1.25	19
Ref	All	All	1.79	1.94	1.11	3.05	0.52	24
Art	High (AH)	All	2.33	0.34	2.16	2.50	0.24	2
"	"	Surface	2.50	0.00	2.50	2.50	0.00	1
"	"	Mid-depth	2.16	0.00	2.16	2.16	0.00	1
"	"	Deep	--††	--††	--††	--††	--††	--††
Art	Inter-tidal (AI)	All	2.46	2.80	1.42	4.22	1.06	9
"	"	Surface	1.55	0.23	1.42	1.65	0.12	3
"	"	Mid-depth	2.06	1.01	1.64	2.65	0.52	3
"	"	Deep	3.76	0.88	3.34	4.22	0.44	3
Art	Sub-tidal (AS)	All	3.68	3.68	1.88	5.56	1.29	8
"	"	Surface	2.01	0.26	1.88	2.14	0.18	2
"	"	Mid-depth	4.52	2.04	3.52	5.56	1.02	3
"	"	Deep	3.96	1.69	2.95	4.64	0.89	3
Ref	High (RH)	All	1.78	1.72	1.33	3.05	0.56	8
"	"	Surface	1.45	0.14	1.38	1.52	0.10	2
"	"	Mid-depth	1.68	0.57	1.33	1.90	0.31	3
"	"	Deep	2.11	1.59	1.46	3.05	0.84	3
Ref	Inter-tidal (RI)	All	1.97	1.67	1.11	2.78	0.60	8
"	"	Surface	2.18	1.45	1.33	2.78	0.76	3
"	"	Mid-depth	1.62	1.04	1.11	2.15	0.52	3
"	"	Deep	2.18	0.71	1.83	2.54	0.50	2
Ref	Sub-tidal (RS)	All	1.63	1.05	1.31	2.36	0.37	8
"	"	Surface	1.84	1.05	1.31	2.36	0.74	2
"	"	Mid-depth	1.67	0.61	1.33	1.94	0.31	3
"	"	Deep	1.44	0.16	1.35	1.51	0.08	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'19

Statistics for Interstitial Water Dissolved Nitrate Plus Nitrite at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

DISSOLVED NITRATE PLUS NITRITE (mg/l)								
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	0.109	0.166	0.063	0.229	0.037	37
Art	All	All	0.100	0.065	0.063	0.128	0.020	18
Ref	All	All	0.119	0.165	0.064	0.229	0.047	19
Art	High (AH)	All	0.112	0.009	0.108	0.117	0.006	2
"	"	Surface	0.117	0.000	0.117	0.117	0.000	1
"	"	Mid-depth	---††	---††	---††	---††	---††	--††
"	"	Deep	0.108	0.000	0.108	0.108	0.000	1
Art	Inter-tidal (AI)	All	0.100	0.061	0.067	0.128	0.022	8
"	"	Surface	0.121	0.021	0.107	0.128	0.012	3
"	"	Mid-depth	0.098	0.012	0.092	0.104	0.006	3
"	"	Deep	0.071	0.008	0.067	0.075	0.006	2
Art	Sub-tidal (AS)	All	0.096	0.062	0.063	0.125	0.019	8
"	"	Surface	0.109	0.017	0.103	0.115	0.008	2
"	"	Mid-depth	0.103	0.042	0.083	0.125	0.021	3
"	"	Deep	0.080	0.029	0.063	0.092	0.015	3
Ref	High (RH)	All	0.169	0.107	0.122	0.229	0.044	6
"	"	Surface	0.140	0.030	0.125	0.155	0.021	2
"	"	Mid-depth	0.173	0.107	0.122	0.229	0.054	3
"	"	Deep	0.213	0.000	0.213	0.213	0.000	1
Ref	Inter-tidal (RI)	All	0.114	0.073	0.072	0.145	0.031	4
"	"	Surface	0.127	0.034	0.111	0.145	0.017	3
"	"	Mid-depth	0.072	0.000	0.072	0.072	0.000	1
"	"	Deep	---††	---††	---††	---††	---††	--††
Ref	Sub-tidal (RS)	All	0.087	0.055	0.064	0.119	0.021	9
"	"	Surface	0.102	0.019	0.090	0.109	0.011	3
"	"	Mid-depth	0.089	0.053	0.066	0.119	0.027	3
"	"	Deep	0.071	0.019	0.064	0.083	0.010	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'20

Statistics for Interstitial Water Dissolved Nitrate Plus Nitrite at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

DISSOLVED NITRATE PLUS NITRITE (mg/l)

Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	0.105	0.193	0.207	0.220	0.050	43
Art	All	All	0.106	0.165	0.034	0.199	0.049	19
Ref	All	All	0.104	0.193	0.027	0.220	0.052	24
Art	High (AH)	All	0.143	0.101	0.092	0.192	0.071	2
"	"	Surface	0.092	0.000	0.092	0.092	0.000	1
"	"	Mid-depth	0.193	0.000	0.193	0.193	0.000	1
"	"	Deep	---††	---††	---††	---††	---††	--††
Art	Inter-tidal (AI)	All	0.120	0.150	0.049	0.199	0.051	9
"	"	Surface	0.134	0.104	0.095	0.199	0.057	3
"	"	Mid-depth	0.095	0.044	0.072	0.116	0.022	3
"	"	Deep	0.131	0.144	01049	0.193	0.074	3
Art	Sub-tidal (AS)	All	0.082	0.081	0.034	0.115	0.040	3
"	"	Surface	0.090	0.038	0.071	0.109	0.027	2
"	"	Mid-depth	0.090	0.071	0.044	0.115	0.040	3
"	"	Deep	0.070	0.081	0.034	0.115	0.041	3
Ref	High (RH)	All	0.104	0.087	0.063	0.150	0.026	8
"	"	Surface	0.124	0.052	0.098	0.150	0.037	2
"	"	Mid-depth	0.084	0.040	0.063	0.103	0.020	3
"	"	Deep	0.111	0.036	0.093	0.129	0.018	3
Ref	Inter-tidal (RI)	All	0.134	0.169	0.051	0.220	0.070	8
"	"	Surface	0.136	0.148	0.057	0.205	0.075	3
"	"	Mid-depth	0.131	0.131	0.075	0.206	0.068	3
"	"	Deep	0.136	0.169	0.051	0.220	0.120	2
Ref	Sub-tidal (RS)	All	0.073	0.106	0.027	0.133	0.035	8
"	"	Surface	0.051	0.013	0.044	0.057	0.009	2
"	"	Mid-depth	0.064	0.062	0.027	0.089	0.033	3
"	"	Deep	0.098	0.080	0.053	0.133	0.041	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

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HABITAT DEVELOPMENT FIELD INVESTIGATIONS WINDMILL POINT MARSH D--ETC(U)

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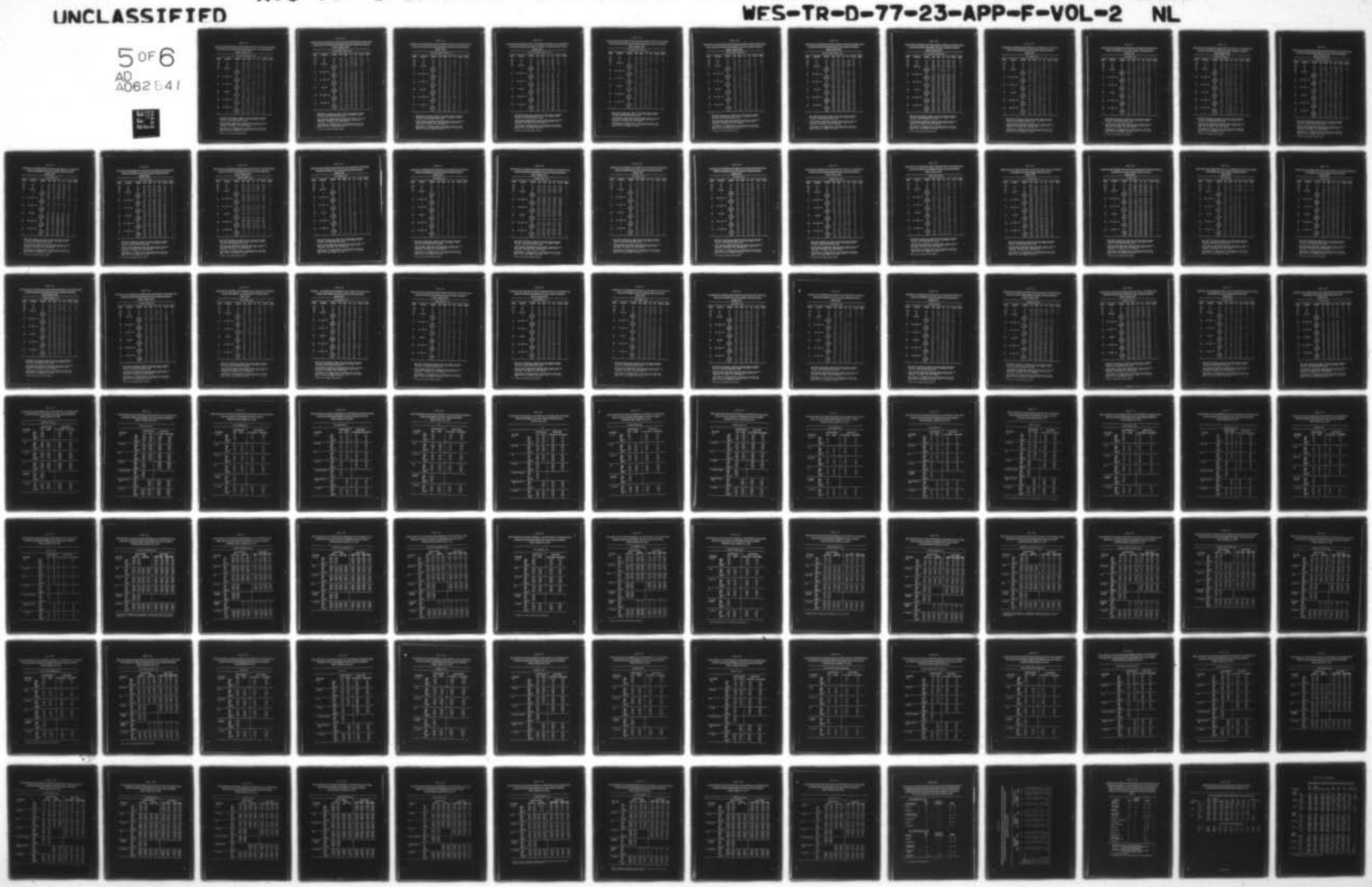

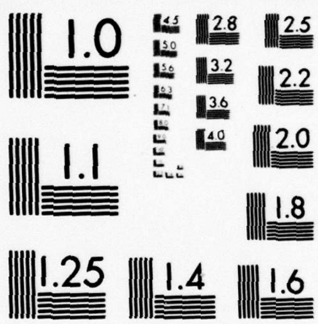

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Table C'21

Statistics for Interstitial Water Total Dissolved Nitrogen at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			TOTAL DISSOLVED NITROGEN (mg/1)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	11.31	31.35	0.19	31.54	8.96	39
Art	All	All	12.66	24.6	3.14	27.74	8.14	18
Ref	All	All	10.16	31.35	0.19	31.54	9.65	21
Art	High (AH)	All	6.67	9.7	3.14	12.84	5.36	3
"	"	Surface	3.14	0.00	3.14	3.14	0.00	1
"	"	Mid-depth	---††	---††	--††	---††	--††	--††
"	"	Deep	8.44	8.80	4.04	12.84	6.22	2
Art	Inter-tidal (AI)	All	15.17	17.7	7.14	24.84	7.67	6
"	"	Surface	8.14	0.00	8.14	8.14	0.00	1
"	"	Mid-depth	15.24	17.7	7.14	24.84	8.94	3
"	"	Deep	18.59	11.1	13.04	24.14	7.85	2
Art	Sub-tidal (AS)	All	12.97	24.4	3.34	24.74	8.85	9
"	"	Surface	3.84	0.9	3.34	4.24	0.46	3
"	"	Mid-depth	13.81	13.5	7.04	20.54	6.75	3
"	"	Deep	21.27	12.30	15.44	27.74	6.17	3
Ref	High (RH)	All	1.86	3.85	0.19	4.04	1.29	7
"	"	Surface	1.66	2.13	0.66	2.79	1.07	3
"	"	Mid-depth	1.33	1.87	0.19	2.06	1.00	3
"	"	Deep	4.04	0.00	4.04	4.04	0.00	1
Ref	Inter-tidal (RI)	All	12.33	30.62	0.92	31.54	14.90	5
"	"	Surface	11.33	30.62	0.92	31.54	17.50	3
"	"	Mid-depth	13.83	23.12	2.27	25.39	16.35	2
"	"	Deep	---††	---††	---††	---††	---††	--††
Ref	Sub-tidal (RS)	All	15.40	14.16	8.21	22.37	5.14	9
"	"	Surface	18.59	8.63	13.74	22.37	4.41	3
"	"	Mid-depth	11.51	1.56	10.92	12.48	0.85	3
"	"	Deep	16.10	12.41	8.21	20.62	6.86	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'22

Statistics for Interstitial Water Total Dissolved Nitrogen at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

TOTAL DISSOLVED NITROGEN (mg/l)

Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	4.41	7.13	1.06	8.19	2.08	39
Art	All	All	5.56	7.05	1.14	8.19	2.41	17
Ref	All	All	3.52	4.36	1.06	5.42	1.21	22
Art	High (AH)	All	5.25	0.00	5.25	5.25	0.00	1
"	"	Surface	5.25	0.00	5.25	5.25	0.00	1
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	--††	--††	--††	--††	--††	--††
Art	Inter-tidal (AI)	All	4.36	6.73	1.14	7.87	2.60	9
"	"	Surface	2.21	1.83	1.14	2.97	1.00	3
"	"	Mid-depth	3.31	2.91	1.90	4.81	1.46	3
"	"	Deep	7.55	0.80	7.07	7.87	0.42	3
Art	Sub-tidal (AS)	All	7.15	2.97	5.22	8.19	1.18	7
"	"	Surface	5.22	0.00	5.22	5.22	0.00	1
"	"	Mid-depth	7.04	2.22	5.73	7.95	1.16	3
"	"	Deep	7.91	0.60	7.59	8.19	0.30	3
Ref	High (RH)	All	2.97	2.27	1.26	3.53	0.85	6
"	"	Surface	1.26	0.00	1.26	1.26	0.00	1
"	"	Mid-depth	3.23	0.21	3.13	3.34	0.10	3
"	"	Deep	3.44	0.18	3.35	3.53	0.13	2
Ref	Inter-tidal (RI)	All	3.01	4.21	1.06	5.27	1.34	8
"	"	Surface	1.75	1.39	1.06	2.45	0.70	3
"	"	Mid-depth	3.57	1.20	3.11	4.31	0.65	3
"	"	Deep	4.05	2.44	2.83	5.27	1.72	2
Ref	Sub-tidal (RS)	All	4.44	2.21	3.21	5.42	0.73	8
"	"	Surface	3.70	0.99	3.21	4.20	0.70	2
"	"	Mid-depth	4.32	1.19	3.84	5.03	0.63	3
"	"	Deep	5.05	0.64	4.78	5.42	0.33	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'23

Statistics for Sediment Bulk Total Kjeldahl Nitrogen at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

BULK TOTAL KJELDAHL NITROGEN (μg/g)

Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	1140	2640	204	2840	733	52
Art	All	All	765	1210	204	1410	360	27
Ref	All	All	1540	2410	431	2840	823	25
Art	High (AH)	All	446	670	204	874	206	9
"	"	Surface	258	150	204	354	84	3
"	"	Mid-depth	447	219	332	551	110	3
"	"	Deep	633	400	474	874	212	3
Art	Inter-tidal (AI)	All	761	777	404	1180	264	9
"	"	Surface	572	375	404	779	191	3
"	"	Mid-depth	1046	229	952	1180	120	3
"	"	Deep	667	400	478	878	201	3
Art	Sub-tidal (AS)	All	1090	807	604	1410	278	9
"	"	Surface	1160	292	967	1260	167	3
"	"	Mid-depth	1170	508	903	1410	255	3
"	"	Deep	935	782	604	1390	404	3
Ref	High (RH)	All	1320	1650	431	2080	695	9
"	"	Surface	1730	835	1250	2080	433	3
"	"	Mid-depth	1310	1440	431	1880	744	3
"	"	Deep	911	1400	434	1840	800	3
Ref	Inter-tidal (RI)	All	816	1280	482	1760	432	7
"	"	Surface	953	1280	482	1760	704	3
"	"	Mid-depth	722	81	681	762	51	2
"	"	Deep	704	217	596	813	153	2
Ref	Sub-tidal (RS)	All	2320	1590	1250	2840	462	9
"	"	Surface	2410	481	2100	2580	268	3
"	"	Mid-depth	2490	663	2180	2840	332	3
"	"	Deep	2050	1360	1250	2600	714	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

Table C'24

Statistics for Sediment Bulk Total Kjeldahl Nitrogen at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

			BULK TOTAL KJELDAHL NITROGEN (μg/g)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	775	1860	118	1980	420	49
Art	All	All	531	1060	118	1180	285	24
Ref	All	All	1010	1550	433	1980	398	25
Art	High (AH)	All	215	159	118	277	58	6
"	"	Surface	186	141	118	259	70	3
"	"	Mid-depth	245	65	212	277	32	3
"	"	Deep	---††	---††	---††	---††	---††	--††
Art	Inter-tidal (AI)	All	542	511	336	847	191	9
"	"	Surface	553	459	388	847	255	3
"	"	Mid-depth	612	502	336	838	254	3
"	"	Deep	461	13	455	468	6	3
Art	Sub-tidal (AS)	All	730	867	313	1180	273	9
"	"	Surface	885	636	544	1180	320	3
"	"	Mid-depth	529	427	313	740	213	3
"	"	Deep	778	402	638	1040	227	3
Ref	High (RH)	All	1090	1260	433	1690	363	9
"	"	Surface	1100	578	892	1470	325	3
"	"	Mid-depth	1240	767	923	1690	398	3
"	"	Deep	928	817	433	1250	435	3
Ref	Inter-tidal (RI)	All	755	686	544	1230	228	8
"	"	Surface	679	241	544	785	123	3
"	"	Mid-depth	892	663	567	1230	332	3
"	"	Deep	662	209	558	767	148	2
Ref	Sub-tidal (RS)	All	1180	1410	571	1980	478	8
"	"	Surface	1100	190	1010	1200	134	2
"	"	Mid-depth	1270	811	749	1560	454	3
"	"	Deep	1130	1410	571	1980	749	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'25

Statistics for Interstitial Water Dissolved Organic Carbon at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			DISSOLVED ORGANIC CARBON (mg/l)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	32.4	65.1	14.0	79.1	15.3	51
Art	All	All	36.3	57.0	18.5	75.5	15.6	26
Ref	All	All	28.4	65.1	14.0	79.1	14.1	25
Art	High (AH)	All	33.9	56.4	18.5	74.9	19.0	8
"	"	Surface	20.7	1.8	19.8	21.6	1.3	2
"	"	Mid-depth	46.9	56.4	18.5	74.9	28.2	3
"	"	Deep	29.7	6.3	27.5	33.8	3.6	3
Art	Inter-tidal (AI)	All	33.6	53.9	21.6	75.5	16.6	9
"	"	Surface	25.1	10.4	21.6	32.0	6.0	3
"	"	Mid-depth	44.1	53.7	21.8	75.5	28.0	3
"	"	Deep	31.6	5.0	28.4	33.4	2.8	3
Art	Sub-tidal (AS)	All	41.2	33.1	28.2	61.3	11.2	9
"	"	Surface	31.9	7.2	28.2	35.4	3.6	3
"	"	Mid-depth	51.6	20.4	40.9	61.3	10.2	3
"	"	Deep	40.1	19.3	29.6	48.9	9.8	3
Ref	High (RH)	All	32.2	65.1	14.0	79.1	20.6	9
"	"	Surface	42.4	62.3	16.8	79.1	32.6	3
"	"	Mid-depth	20.9	3.4	19.8	23.2	2.0	3
"	"	Deep	33.2	29.7	14.0	43.7	16.6	3
Ref	Inter-tidal (RI)	All	28.7	17.2	20.1	37.3	6.7	7
"	"	Surface	31.3	16.0	21.3	37.3	8.7	3
"	"	Mid-depth	29.4	6.5	26.1	32.6	4.6	2
"	"	Deep	24.1	8.0	20.1	28.1	5.6	2
Ref	Sub-tidal (RS)	All	24.4	35.0	15.7	50.7	10.2	9
"	"	Surface	19.5	7.8	15.7	23.5	3.9	3
"	"	Mid-depth	20.7	2.0	19.8	21.8	1.0	3
"	"	Deep	32.9	26.8	23.9	50.7	15.4	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

Table C'26

Statistics for Interstitial Water Dissolved Organic Carbon at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

			DISSOLVED ORGANIC CARBON (mg/l)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	18.1	34.2	2.3	36.5	6.2	49
Art	All	All	19.9	27.3	9.2	36.5	7.1	24
Ref	All	All	16.2	22.2	2.3	24.5	4.6	25
Art	High (AH)	All	13.9	12.7	9.2	21.9	4.6	6
"	"	Surface	13.0	6.7	9.2	15.9	3.4	3
"	"	Mid-depth	14.8	11.3	10.6	21.9	6.2	3
"	"	Deep	--††	--††	--††	--††	--††	--††
Art	Inter-tidal (AI)	All	20.3	17.7	10.5	28.2	6.3	9
"	"	Surface	13.2	4.4	10.5	14.9	2.4	3
"	"	Mid-depth	22.4	7.8	17.5	25.3	4.2	3
"	"	Deep	25.3	7.4	20.8	28.2	4.0	3
Art	Sub-tidal (AS)	All	23.6	19.4	17.1	36.5	7.1	9
"	"	Surface	20.3	4.9	17.7	22.6	2.5	3
"	"	Mid-depth	26.3	19.4	17.1	36.5	9.7	3
"	"	Deep	24.2	16.5	17.5	34.0	8.6	3
Ref	High (RH)	All	15.7	7.3	11.7	19.0	2.6	9
"	"	Surface	15.0	7.3	11.7	19.0	3.7	3
"	"	Mid-depth	16.6	4.9	14.1	19.0	2.4	3
"	"	Deep	15.5	4.8	13.2	18.0	2.4	3
Ref	Inter-tidal (RI)	All	16.6	7.7	13.7	21.4	3.1	8
"	"	Surface	16.9	7.7	13.7	21.4	4.0	3
"	"	Mid-depth	15.5	2.5	14.1	16.6	1.3	3
"	"	Deep	17.8	7.1	14.3	21.4	5.0	2
Ref	Sub-tidal (RS)	All	16.5	22.2	2.3	24.5	7.5	8
"	"	Surface	15.6	9.7	9.3	19.0	5.5	3
"	"	Mid-depth	21.3	5.6	18.5	24.1	4.0	2
"	"	Deep	14.2	22.2	2.3	24.5	11.2	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'27

Statistics for Sediment Bulk Total Organic Carbon at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			BULK TOTAL ORGANIC CARBON (µg/g)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	11200	10900	6810	17700	2370	52
Art	All	All	10400	7000	6810	13800	2050	27
Ref	All	All	12000	9920	7820	17700	2460	25
Art	High (AH)	All	10100	5550	6810	12400	2160	9
"	"	Surface	8980	5510	6810	12300	2940	3
"	"	Mid-depth	10500	4780	7570	12400	2590	3
"	"	Deep	10800	1030	10200	11200	570	3
Art	Inter-tidal (AI)	All	10800	6280	7530	13800	2470	9
"	"	Surface	10600	4670	8400	13100	2360	3
"	"	Mid-depth	10100	5170	7530	12700	2590	3
"	"	Deep	11900	5480	8330	13800	3090	3
Art	Sub-tidal (AS)	All	10300	4800	7710	12500	1590	9
"	"	Surface	9860	4800	7710	12500	2440	3
"	"	Mid-depth	10100	2830	8330	11200	1570	3
"	"	Deep	10800	2000	9800	11800	1000	3
Ref	High (RH)	All	11300	7130	7820	15000	2170	9
"	"	Surface	11400	3820	9510	13300	1910	3
"	"	Mid-depth	12700	4590	10400	15000	2300	3
"	"	Deep	9680	3410	7820	11200	1730	3
Ref	Inter-tidal (RI)	All	12000	6670	8820	15500	2510	7
"	"	Surface	10300	3070	8820	11900	1540	3
"	"	Mid-depth	12800	4580	10500	15100	3240	2
"	"	Deep	13900	3230	12300	15500	2280	2
Ref	Sub-tidal (RS)	All	12700	7880	9850	17700	2720	9
"	"	Surface	11600	2600	9850	12500	1490	3
"	"	Mid-depth	11600	2480	10500	13000	1280	3
"	"	Deep	15100	6840	10900	17700	3670	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

Table C'28

Statistics for Sediment Bulk Total Organic Carbon at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

			BULK TOTAL ORGANIC CARBON (ug/g)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	12460	9396	9238	18520	2070	49
Art	All	All	12170	7030	9128	16160	1954	24
Ref	All	All	12750	9246	9278	18520	2176	25
Art	High (AH)	All	12480	2443	11120	13560	1063	6
"	"	Surface	11580	1111	11120	12230	580	3
"	"	Mid-depth	13380	436	13130	13560	226	3
"	"	Deep	---††	---††	---††	---††	---††	--††
Art	Inter-tidal (AI)	All	12240	7030	9128	16160	2700	9
"	"	Surface	10720	2999	9128	12130	1510	3
"	"	Mid-depth	12270	6832	9326	16160	3513	3
"	"	Deep	13730	4931	10520	15460	2783	3
Art	Sub-tidal (AS)	All	11880	4880	9805	14680	1678	9
"	"	Surface	11510	4880	9805	14680	2754	3
"	"	Mid-depth	11760	1817	11110	12930	1014	3
"	"	Deep	12380	2700	20760	13460	1429	3
Ref	High (RH)	All	11890	3531	9884	13420	1307	9
"	"	Surface	10400	1335	9884	11220	716	3
"	"	Mid-depth	12900	418	12740	13160	226	3
"	"	Deep	12360	2088	11330	13420	1044	3
Ref	Inter-tidal (RI)	All	12350	7437	9278	16720	2356	8
"	"	Surface	10960	4075	9278	13350	2131	3
"	"	Mid-depth	13940	5686	11030	16720	2845	3
"	"	Deep	12060	271	11930	12200	192	2
Ref	Sub-tidal (RS)	All	14120	7372	11150	18520	2335	8
"	"	Surface	13860	1680	13020	14700	1188	2
"	"	Mid-depth	13320	2526	12460	14980	1445	3
"	"	Deep	15100	7372	11150	18520	3715	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'29

Statistics for Sediment Bulk Cadmium at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			BULK CADMIUM (µg/g)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	1.25	1.78	0.27	2.05	0.44	52
Art	All	All	1.33	1.73	0.27	2.00	0.47	27
Ref	All	All	1.16	1.41	0.64	2.05	0.39	25
Art	High (AH)	All	0.80	1.26	0.27	1.53	0.35	9
"	"	Surface	0.58	0.62	0.27	0.89	0.31	3
"	"	Mid-depth	0.68	0.09	0.62	0.71	0.05	3
"	"	Deep	1.14	0.64	0.89	1.53	0.34	3
Art	Inter-tidal (AI)	All	1.56	0.56	1.21	1.77	0.21	9
"	"	Surface	1.63	0.24	1.51	1.75	0.12	3
"	"	Mid-depth	1.74	0.07	1.70	1.77	0.04	3
"	"	Deep	1.32	0.23	1.21	1.44	0.12	3
Art	Sub-tidal (AS)	All	1.64	0.84	1.16	2.00	0.26	9
"	"	Surface	1.71	0.17	1.62	1.79	0.08	3
"	"	Mid-depth	1.74	0.57	1.43	2.00	0.29	3
"	"	Deep	1.47	0.64	1.16	1.80	0.32	3
Ref	High (RH)	All	0.92	0.51	0.64	1.15	0.14	9
"	"	Surface	0.85	0.36	0.64	1.00	0.19	3
"	"	Mid-depth	1.00	0.33	0.82	1.15	0.17	3
"	"	Deep	0.91	0.05	0.88	0.93	0.02	3
Ref	Inter-tidal (RI)	All	0.95	0.35	0.82	1.17	0.13	7
"	"	Surface	1.03	0.27	0.90	1.17	0.14	3
"	"	Mid-depth	0.93	0.22	0.82	1.04	0.16	2
"	"	Deep	0.86	0.08	0.82	0.90	0.06	2
Ref	Sub-tidal (RS)	All	1.57	1.23	0.82	2.05	0.35	9
"	"	Surface	1.55	0.44	1.36	1.80	0.23	3
"	"	Mid-depth	1.32	0.83	0.82	1.65	0.44	3
"	"	Deep	1.84	0.40	1.65	2.05	0.20	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

Table C'30

Statistics for Sediment Bulk Cadmium at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

BULK CADMIUM (µg/g)

Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	1.35	1.54	0.71	2.25	0.39	49
Art	All	All	1.46	1.54	0.71	2.25	0.43	24
Ref	All	All	1.24	1.17	0.89	2.06	0.32	25
Art	High (AH)	All	0.86	0.50	0.71	1.21	0.19	6
"	"	Surface	0.81	0.20	0.72	0.92	0.10	3
"	"	Mid-depth	0.91	0.50	0.71	1.21	0.27	3
"	"	Deep	--††	--††	--††	--††	--††	--††
Art	Inter-tidal (AI)	All	1.63	0.74	1.38	2.12	0.22	9
"	"	Surface	1.60	0.11	1.56	1.67	0.06	3
"	"	Mid-depth	1.84	0.46	1.66	2.12	0.25	3
"	"	Deep	1.45	0.19	1.38	1.57	0.10	3
Art	Sub-tidal (AS)	All	1.70	1.09	1.16	2.25	0.31	9
"	"	Surface	1.76	0.20	1.68	1.88	1.11	3
"	"	Mid-depth	1.60	0.74	1.16	1.90	0.39	3
"	"	Deep	1.74	0.82	1.43	2.25	0.44	3
Ref	High (RH)	All	1.23	0.43	1.06	1.49	0.18	9
"	"	Surface	1.33	0.33	1.12	1.45	0.18	3
"	"	Mid-depth	1.26	0.40	1.09	1.49	0.21	3
"	"	Deep	1.09	0.06	1.06	1.12	0.03	3
Ref	Inter-tidal (RI)	All	1.26	1.17	0.89	2.06	0.43	8
"	"	Surface	1.49	0.91	1.15	2.06	0.50	3
"	"	Mid-depth	1.25	0.87	0.89	1.76	0.45	3
"	"	Deep	0.94	0.06	0.91	0.97	0.04	2
Ref	Sub-tidal (RS)	All	1.23	0.90	0.89	1.79	0.37	8
"	"	Surface	1.76	0.06	1.73	1.79	0.04	2
"	"	Mid-depth	1.13	0.45	0.98	1.43	0.26	3
"	"	Deep	0.97	0.24	0.89	1.13	0.14	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'31

Statistics for Interstitial Water Dissolved Calcium at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

DISSOLVED CALCIUM (mg/1)

Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	53.4	125.8	5.2	131.0	36.6	41
Art	All	All	81.5	94.0	37.0	131.0	28.7	20
Ref	All	All	26.5	48.5	5.2	53.7	18.6	21
Art	High (AH)	All	63.8	46.0	40.4	86.4	21.9	5
"	"	Surface	--††	--††	--††	--††	--††	--††
"	"	Mid-depth	53.0	25.2	40.4	65.6	17.8	2
"	"	Deep	71.1	43.6	42.8	86.4	24.5	3
Art	Inter-tidal (AI)	All	74.2	73.0	37.0	110.0	29.4	8
"	"	Surface	42.4	10.9	37.0	47.9	7.7	2
"	"	Mid-depth	69.6	55.6	40.5	96.1	27.9	3
"	"	Deep	100.1	24.7	85.3	110.0	13.1	3
Art	Sub-tidal (AS)	All	102.5	56.5	74.5	131.0	20.9	7
"	"	Surface	74.5	0.0	74.5	74.5	0.0	1
"	"	Mid-depth	100.9	37.4	82.6	120.0	18.7	3
"	"	Deep	113.5	38.6	92.4	131.0	19.5	3
Ref	High (RH)	All	10.3	13.8	5.2	19.0	4.9	7
"	"	Surface	13.9	0.0	13.9	13.9	0.0	1
"	"	Mid-depth	12.8	10.8	8.2	19.0	5.6	3
"	"	Deep	6.6	3.7	5.2	8.9	2.0	3
Ref	Inter-tidal (RI)	All	12.7	5.7	9.6	15.3	2.1	5
"	"	Surface	11.9	0.0	11.9	11.9	0.0	1
"	"	Mid-depth	11.6	4.0	9.6	13.6	2.9	2
"	"	Deep	14.3	2.0	13.3	15.3	1.4	2
Ref	Sub-tidal (RS)	All	46.8	14.2	39.5	53.7	5.8	9
"	"	Surface	48.4	14.2	39.5	53.7	7.8	3
"	"	Mid-depth	50.5	3.4	49.3	52.7	1.9	3
"	"	Deep	41.4	1.7	40.5	42.2	0.9	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'32

Statistics for Interstitial Water Dissolved Calcium at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

			DISSOLVED CALCIUM (mg/ℓ)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	35.1	112.4	4.4	116.8	34.0	43
Art	All	All	65.2	101.9	14.9	116.8	33.0	18
Ref	All	All	13.4	34.2	4.4	38.6	9.0	25
Art	High (AH)	All	24.8	19.9	14.9	34.8	14.1	2
"	"	Surface	14.9	0.0	14.9	14.9	0.0	1
"	"	Mid-depth	34.8	0.0	34.8	34.8	0.0	1
"	"	Deep	--††	--††	--††	--††	--††	--††
Art	Inter-tidal (AI)	All	76.8	88.8	28.0	116.8	33.8	8
"	"	Surface	42.3	23.0	28.0	51.0	12.5	3
"	"	Mid-depth	73.7	5.6	70.8	76.5	4.0	2
"	"	Deep	113.5	9.4	107.4	116.8	5.3	3
Art	Sub-tidal (AS)	All	63.7	73.8	26.1	99.9	29.1	8
"	"	Surface	46.9	29.8	27.4	57.2	16.9	3
"	"	Mid-depth	74.2	35.2	56.6	91.8	24.9	2
"	"	Deep	73.4	73.8	26.1	99.9	41.1	3
Ref	High (RH)	All	8.2	13.6	4.4	18.0	3.9	9
"	"	Surface	10.8	11.2	6.8	18.0	6.3	3
"	"	Mid-depth	7.3	3.1	5.6	8.7	1.6	3
"	"	Deep	6.6	4.4	4.4	8.7	2.2	3
Ref	Inter-tidal (RI)	All	17.7	33.6	5.0	38.6	13.4	8
"	"	Surface	21.0	28.6	10.0	38.6	15.4	3
"	"	Mid-depth	17.2	31.1	5.6	36.7	17.0	3
"	"	Deep	13.4	16.8	5.0	21.8	11.9	2
Ref	Sub-tidal (RS)	All	15.0	11.2	10.0	21.2	4.3	8
"	"	Surface	18.6	1.3	18.0	19.3	0.9	2
"	"	Mid-depth	15.2	10.0	11.2	21.2	5.3	3
"	"	Deep	12.4	6.6	10.0	16.5	3.6	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'33

Statistics for Sediment Bulk Calcium at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			BULK CALCIUM (µg/g)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	3200	5380	1060	6440	1290	31
Art	All	All	2830	4530	1060	5590	1440	7
Ref	All	All	3310	4750	1690	6440	1250	24
Art	High (AH).	All	2770	4530	1060	5590	1760	5
"	"	Surface	1350	580	1060	1640	410	2
"	"	Mid-depth	5590	0	5590	5590	0	1
"	"	Deep	2780	650	2450	3100	460	2
Art	Inter-tidal (AI)	All	2990	220	2880	3100	160	2
"	"	Surface	---††	---††	---††	---††	---††	--††
"	"	Mid-depth	---††	---††	---††	---††	---††	--††
"	"	Deep	2990	220	2880	3100	160	2
Art	Sub-tidal (AS)	All	---††	---††	---††	---††	---††	--††
"	"	Surface	---††	---††	---††	---††	---††	--††
"	"	Mid-depth	---††	---††	---††	---††	---††	--††
"	"	Deep	---††	---††	---††	---††	---††	--††
Ref	High (RH)	All	4280	3940	2500	6440	1440	8
"	"	Surface	4120	2490	2870	5360	1760	2
"	"	Mid-depth	4960	3290	3150	6440	1670	3
"	"	Deep	3700	2560	2500	5060	1290	3
Ref	Inter-tidal (RI)	All	2530	2700	1690	4390	1140	7
"	"	Surface	3370	2590	1800	4390	1380	3
"	"	Mid-depth	2090	320	1930	2250	230	2
"	"	Deep	1700	30	1690	1720	20	2
Ref	Sub-tidal (RS)	All	3050	1300	2600	3900	440	9
"	"	Surface	3300	80	3260	3340	40	3
"	"	Mid-depth	2810	260	2640	2900	150	3
"	"	Deep	3040	1300	2600	3900	750	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'34

Statistics for Sediment Bulk Calcium at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

			BULK CALCIUM (μg/g)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	2620	3320	1160	4480	900	48
Art	All	All	3140	2430	1870	4300	660	24
Ref	All	All	2100	3320	1160	4480	800	24
Art	High (AH)	All	2300	1140	1870	3010	410	6
"	"	Surface	2200	550	1870	2420	290	3
"	"	Mid-depth	2410	1060	1950	3010	540	3
"	"	Deep	---††	---††	---††	---††	---††	--††
Art	Inter-tidal (AI)	All	3480	860	3040	3900	320	9
"	"	Surface	3190	400	3040	3440	220	3
"	"	Mid-depth	3790	220	3680	3900	110	3
"	"	Deep	3450	540	3230	3770	280	3
Art	Sub-tidal (AS)	All	3350	1810	2490	4300	580	9
"	"	Surface	3530	540	3200	3740	290	3
"	"	Mid-depth	3150	1180	2600	3780	590	3
"	"	Deep	3360	1810	2490	4300	910	3
Ref	High (RH)	All	2080	3220	1260	4480	1010	8
"	"	Surface	3070	2260	1820	4480	1340	3
"	"	Mid-depth	1600	370	1410	1780	260	2
"	"	Deep	1430	500	1260	1760	290	3
Ref	Inter-tidal (RI)	All	2020	2430	1160	3590	850	8
"	"	Surface	2510	1630	1960	3590	930	3
"	"	Mid-depth	1910	1730	1220	2950	920	3
"	"	Deep	1430	540	1160	1700	380	2
Ref	Sub-tidal (RS)	All	2190	1320	1770	3090	420	8
"	"	Surface	2780	620	2470	3090	440	2
"	"	Mid-depth	1940	410	1770	2180	210	3
"	"	Deep	2050	260	1920	2180	130	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'35

Statistics for Interstitial Water Dissolved Chromium at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			DISSOLVED CHROMIUM (mg/l)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	0.035	0.038	0.022	0.060	0.012	15
Art	All	All	0.034	0.029	0.022	0.051	0.009	6
Ref	All	All	0.035	0.037	0.023	0.060	0.014	9
Art	High (AH)	All	0.038	0.020	0.031	0.051	0.011	3
"	"	Surface	---††	---††	---††	---††	---††	--††
"	"	Mid-depth	0.042	0.019	0.032	0.051	0.013	3
"	"	Deep	0.031	0.000	0.031	0.031	0.000	1
Art	Inter-tidal (AI)	All	0.034	0.000	0.034	0.034	0.000	1
"	"	Surface	0.034	0.000	0.034	0.034	0.000	1
"	"	Mid-depth	---††	---††	---††	---††	---††	--††
"	"	Deep	---††	---††	---††	---††	---††	--††
Art	Sub-tidal (AS)	All	0.029	0.014	0.022	0.036	0.010	2
"	"	Surface	0.036	0.000	0.036	0.036	0.000	1
"	"	Mid-depth	0.022	0.000	0.022	0.022	0.000	1
"	"	Deep	---††	---††	---††	---††	---††	--††
Ref	High (RH)	All	0.040	0.033	0.027	0.060	0.015	6
"	"	Surface	---††	---††	---††	---††	---††	--††
"	"	Mid-depth	0.039	0.030	0.027	0.057	0.016	3
"	"	Deep	0.041	0.033	0.027	0.060	0.017	3
Ref	Inter-tidal (RI)	All	0.025	0.005	0.023	0.028	0.003	3
"	"	Surface	0.024	0.000	0.024	0.024	0.000	1
"	"	Mid-depth	0.023	0.000	0.023	0.023	0.000	1
"	"	Deep	0.028	0.000	0.028	0.028	0.000	1
Ref	Sub-tidal (RS)	All	---††	---††	---††	---††	---††	--††
"	"	Surface	---††	---††	---††	---††	---††	--††
"	"	Mid-depth	---††	---††	---††	---††	---††	--††
"	"	Deep	---††	---††	---††	---††	---††	--††

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'36

Statistics for Sediment Bulk Chromium at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			BULK CHROMIUM (ug/g)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	63	46	32	78	12	45
Art	All	All	62	45	32	77	14	20
Ref	All	All	64	39	39	78	10	25
Art	High (AH)	All	36	16	32	48	8	4
"	"	Surface	33	0	33	33	0	1
"	"	Mid-depth	32	0	32	32	0	1
"	"	Deep	48	0	48	48	0	1
Art	Inter-tidal (AI)	All	68	7	64	71	2	7
"	"	Surface	67	3	66	69	2	3
"	"	Mid-depth	70	3	68	71	2	3
"	"	Deep	64	0	64	64	0	1
Art	Sub-tidal (AS)	All	69	17	60	77	5	9
"	"	Surface	68	7	65	72	4	3
"	"	Mid-depth	70	17	60	77	9	3
"	"	Deep	68	9	64	73	5	3
Ref	High (RH)	All	55	27	39	66	10	9
"	"	Surface	43	11	39	50	6	3
"	"	Mid-depth	61	8	58	66	4	3
"	"	Deep	60	5	58	63	3	3
Ref	Inter-tidal (RI)	All	66	7	63	70	3	7
"	"	Surface	64	2	63	65	1	3
"	"	Mid-depth	66	3	65	68	2	2
"	"	Deep	68	4	66	70	3	2
Ref	Sub-tidal (RS)	All	73	14	64	78	5	9
"	"	Surface	77	2	76	78	1	3
"	"	Mid-depth	70	13	64	77	7	3
"	"	Deep	71	1	71	72	1	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

Table C'37

Statistics for Sediment Bulk Chromium at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

			BULK CHROMIUM (µg/g)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	40	28	26	54	8	49
Art	All	All	40	28	26	54	9	24
Ref	All	All	40	25	27	52	7	25
Art	High (AH)	All	28	9	26	35	3	6
"	"	Surface	26	0	26	26	0	3
"	"	Mid-depth	30	8	27	35	5	3
"	"	Deep	--††	--††	--††	--††	--††	--††
Art	Inter-tidal (AI)	All	44	13	38	50	4	9
"	"	Surface	43	6	40	45	3	3
"	"	Mid-depth	48	5	45	50	3	3
"	"	Deep	41	7	38	44	3	3
Art	Sub-tidal (AS)	All	44	28	26	54	9	9
"	"	Surface	42	12	35	47	6	3
"	"	Mid-depth	41	25	26	51	13	3
"	"	Deep	49	11	43	54	5	3
Ref	High (RH)	All	32	16	27	43	5	9
"	"	Surface	35	16	27	43	8	3
"	"	Mid-depth	31	6	28	34	3	3
"	"	Deep	32	7	29	36	4	3
Ref	Inter-tidal (RI)	All	43	12	36	48	3	8
"	"	Surface	45	5	43	48	3	3
"	"	Mid-depth	42	9	36	45	5	3
"	"	Deep	43	1	42	43	0	2
Ref	Sub-tidal (RS)	All	47	10	42	52	4	8
"	"	Surface	50	3	49	52	2	2
"	"	Mid-depth	47	6	44	51	3	3
"	"	Deep	44	6	42	46	2	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'38

Statistics for Interstitial Water Dissolved Copper at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			DISSOLVED COPPER (mg/l)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	0.033	0.124	0.013	0.137	0.034	22
Art	All	All	0.029	0.124	0.013	0.137	0.029	17
Ref	All	All	0.045	0.117	0.016	0.133	0.049	5
Art	High (AH)	All	0.024	0.026	0.013	0.039	0.014	3
"	"	Surface	---††	---††	---††	---††	---††	--††
"	"	Mid-depth	---††	---††	---††	---††	---††	--††
"	"	Deep	0.024	0.026	0.013	0.039	0.014	3
Art	Inter-tidal (AI)	All	0.020	0.019	0.013	0.032	0.006	7
"	"	Surface	0.025	0.000	0.025	0.025	0.000	1
"	"	Mid-depth	0.017	0.007	0.013	0.020	0.004	3
"	"	Deep	0.022	0.017	0.015	0.032	0.009	3
Art	Sub-tidal (AS)	All	0.040	0.122	0.015	0.137	0.044	7
"	"	Surface	0.018	0.000	0.018	0.018	0.000	1
"	"	Mid-depth	0.070	0.114	0.023	0.137	0.060	3
"	"	Deep	0.018	0.007	0.015	0.022	0.004	3
Ref	High (RH)	All	0.016	0.000	0.016	0.016	0.000	1
"	"	Surface	---††	---††	---††	---††	---††	--††
"	"	Mid-depth	0.016	0.000	0.016	0.016	0.000	1
"	"	Deep	---††	---††	---††	---††	---††	--††
Ref	Inter-tidal (RI)	All	0.077	0.112	0.021	0.113	0.079	2
"	"	Surface	0.021	0.000	0.021	0.021	0.000	1
"	"	Mid-depth	---††	---††	---††	---††	---††	--††
"	"	Deep	0.133	0.000	0.133	0.133	0.000	1
Ref	Sub-tidal (RS)	All	0.029	0.011	0.023	0.034	0.008	2
"	"	Surface	0.034	0.000	0.034	0.034	0.000	1
"	"	Mid-depth	0.023	0.000	0.023	0.023	0.000	1
"	"	Deep	---††	---††	---††	---††	---††	--††

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'39

Statistics for Sediment Bulk Copper at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			BULK COPPER (μg/g)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	42.7	64.5	9.1	73.6	14.3	52
Art	All	All	40.2	47.1	9.1	56.2	13.5	27
Ref	All	All	45.4	45.5	28.1	73.6	14.8	25
Art	High (AH)	All	24.4	37.1	9.1	46.2	10.6	9
"	"	Surface	18.0	18.9	9.1	28.0	9.5	3
"	"	Mid-depth	20.1	4.2	17.7	21.9	2.2	3
"	"	Deep	35.0	19.0	27.2	46.2	9.9	3
Art	Inter-tidal (AI)	All	45.7	12.7	37.0	49.7	4.7	9
"	"	Surface	47.1	3.5	45.2	28.7	1.8	3
"	"	Mid-depth	49.3	0.7	49.0	49.7	0.4	3
"	"	Deep	40.6	9.1	37.0	46.1	4.9	3
Art	Sub-tidal (AS)	All	50.5	11.4	44.8	56.2	4.9	9
"	"	Surface	50.4	9.5	46.2	55.7	4.9	3
"	"	Mid-depth	52.0	9.6	45.8	55.4	5.4	3
"	"	Deep	49.0	11.4	44.8	56.2	6.2	3
Ref	High (RH)	All	36.3	9.2	31.9	41.1	3.4	9
"	"	Surface	38.5	5.6	35.5	41.1	2.8	3
"	"	Mid-depth	37.8	4.8	35.1	39.9	2.5	3
"	"	Deep	32.6	1.6	31.9	33.5	0.8	3
Ref	Inter-tidal (RI)	All	34.5	14.2	28.1	42.3	4.6	7
"	"	Surface	34.9	14.2	28.1	42.3	7.1	3
"	"	Mid-depth	32.6	5.4	29.9	35.3	3.8	2
"	"	Deep	36.0	1.3	35.3	36.6	0.9	2
Ref	Sub-tidal (RS)	All	63.1	22.9	50.7	73.6	9.1	9
"	"	Surface	69.9	8.6	65.0	73.6	4.4	3
"	"	Mid-depth	67.8	5.0	66.0	71.0	2.8	3
"	"	Deep	51.6	1.8	50.7	52.5	0.9	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

Table C'40

Statistics for Sediment Bulk Copper at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

			BULK COPPER (μg/g)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	41.0	46.8	18.8	65.6	11.5	48
Art	All	All	40.9	46.8	18.8	65.6	12.7	24
Ref	All	All	41.1	36.1	27.0	63.1	10.5	24
Art	High (AH)	All	23.7	12.5	18.8	31.3	4.6	6
"	"	Surface	23.1	7.5	18.8	26.3	3.9	3
"	"	Mid-depth	24.4	11.5	19.8	31.3	6.1	3
"	"	Deep	--††	--††	--††	--††	--††	--††
Art	Inter-tidal (AI)	All	44.8	20.7	34.9	55.6	6.1	9
"	"	Surface	42.2	9.2	37.4	46.6	4.6	3
"	"	Mid-depth	50.2	8.7	46.9	55.6	4.7	3
"	"	Deep	42.0	12.4	34.9	47.3	6.4	3
Art	Sub-tidal (AS)	All	48.5	38.5	27.1	65.6	10.4	9
"	"	Surface	48.5	3.7	46.5	50.2	1.9	3
"	"	Mid-depth	45.0	30.3	27.1	57.4	15.9	3
"	"	Deep	52.0	20.4	45.2	65.6	11.7	3
Ref	High (RH)	All	41.4	24.4	32.2	56.6	7.9	8
"	"	Surface	48.2	17.5	39.1	56.6	8.8	3
"	"	Mid-depth	40.4	1.0	39.9	40.9	0.7	2
"	"	Deep	35.3	7.5	32.2	39.7	3.9	3
Ref	Inter-tidal (RI)	All	41.8	21.8	30.6	52.4	7.8	8
"	"	Surface	46.0	9.8	42.6	52.4	5.5	3
"	"	Mid-depth	43.3	17.4	34.5	51.9	8.7	3
"	"	Deep	33.4	5.5	30.6	36.1	3.9	2
Ref	Sub-tidal (RS)	All	40.0	36.1	27.0	63.1	15.3	8
"	"	Surface	58.7	8.8	54.3	63.1	6.2	2
"	"	Mid-depth	40.2	26.7	30.3	57.0	14.6	3
"	"	Deep	27.4	1.0	27.0	38.0	0.6	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'41

Statistics for Interstitial Water Dissolved Iron at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			DISSOLVED IRON (mg/l)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	30.1	75.4	00.0	75.4	22.6	44
Art	All	All	30.7	62.7	3.4	66.1	16.6	20
Ref	All	All	33.7	73.5	1.9	75.4	26.1	21
Art	High (AH)	All	13.0	23.2	3.4	26.6	9.1	5
"	"	Surface	--††	--††	--††	--††	--††	--††
"	"	Mid-depth	9.0	2.5	7.7	10.2	1.8	2
"	"	Deep	15.8	23.2	3.4	26.6	11.7	3
Art	Inter-tidal (AI)	All	30.0	27.8	15.2	43.0	9.5	8
"	"	Surface	22.3	14.2	15.2	29.4	10.0	2
"	"	Mid-depth	27.4	14.9	17.7	32.6	8.4	3
"	"	Deep	37.8	11.3	31.7	43.0	5.7	3
Art	Sub-tidal (AS)	All	44.1	38.1	28.0	66.1	15.6	7
"	"	Surface	66.1	0.0	66.1	66.1	0.0	1
"	"	Mid-depth	40.9	32.8	29.4	62.2	18.4	3
"	"	Deep	39.9	18.2	28.0	46.2	10.3	3
Ref	High (RH)	All	5.9	8.6	1.9	10.5	2.6	7
"	"	Surface	6.6	0.0	6.6	6.6	0.0	1
"	"	Mid-depth	4.6	4.2	1.9	6.1	2.4	3
"	"	Deep	7.0	6.4	4.1	10.5	3.2	3
Ref	Inter-tidal (RI)	All	33.4	41.1	15.5	56.6	17.3	5
"	"	Surface	25.4	0.0	25.4	25.4	0.0	1
"	"	Mid-depth	19.3	7.6	15.5	23.1	5.4	2
"	"	Deep	51.5	10.2	46.4	56.6	7.2	2
Ref	Sub-tidal (RS)	All	55.5	59.4	16.0	75.4	18.4	9
"	"	Surface	35.5	35.9	16.0	51.9	18.2	3
"	"	Mid-depth	60.5	10.1	56.5	66.6	5.4	3
"	"	Deep	70.6	8.8	66.6	75.4	4.4	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'42

Statistics for Interstitial Water Dissolved Iron at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

			DISSOLVED IRON (mg/l)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	15.8	45.5	0.1	45.6	13.0	43
Art	All	All	20.8	44.6	1.0	45.6	14.4	18
Ref	All	All	12.3	36.8	0.1	36.8	10.9	25
Art	High (AH)	All	1.3	0.2	1.2	1.4	0.2	2
"	"	Surface	1.2	0.0	1.2	1.2	0.0	1
"	"	Mid-depth	1.4	0.0	1.4	1.4	0.0	1
"	"	Deep	--††	--††	--††	--††	--††	--††
Art	Inter-tidal (AI)	All	28.0	37.2	8.4	45.6	14.3	8
"	"	Surface	13.0	12.3	8.4	20.6	6.7	3
"	"	Mid-depth	30.7	12.7	24.3	37.0	9.0	2
"	"	Deep	41.1	9.5	36.1	45.6	4.8	3
Art	Sub-tidal (AS)	All	18.4	35.6	1.0	36.6	11.3	8
"	"	Surface	14.4	24.5	1.0	25.5	12.4	3
"	"	Mid-depth	32.5	8.1	28.5	36.6	5.7	2
"	"	Deep	13.1	6.2	10.9	17.2	3.5	3
Ref	High (RH)	All	7.4	35.4	0.1	35.4	11.1	9
"	"	Surface	1.2	3.2	0.1	3.3	1.8	3
"	"	Mid-depth	6.4	9.5	1.2	10.7	4.8	3
"	"	Deep	14.6	32.1	3.3	35.4	18.0	3
Ref	Inter-tidal (RI)	All	14.5	35.8	1.0	36.8	11.6	8
"	"	Surface	4.1	5.8	1.0	6.8	2.9	3
"	"	Mid-depth	17.9	10.9	11.8	22.7	5.6	3
"	"	Deep	24.9	23.8	13.0	36.8	16.8	2
Ref	Sub-tidal (RS)	All	15.6	28.2	4.4	32.6	9.1	8
"	"	Surface	4.9	0.9	4.4	5.4	0.7	2
"	"	Mid-depth	20.0	21.5	11.1	32.6	11.2	3
"	"	Deep	18.4	4.4	15.5	19.9	2.5	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'43

Statistics for Sediment Bulk Iron at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			BULK IRON (μg/g)					
Marsh*	**Location****	**Stratum**†	**Mean**	**Range**	**Min**	**Max**	**Std Dev**	**Number**
Both	All	All	35990	51190	8890	60080	11330	52
Art	All	All	33630	36460	8890	45350	10380	27
Ref	All	All	38530	37830	22250	60080	11950	25
Art	High (AH)	All	21270	26520	8890	35410	8231	9
"	"	Surface	15210	13500	8890	22390	6792	3
"	"	Mid-depth	18080	2920	16200	19120	1651	3
"	"	Deep	30520	9670	25740	35410	4836	3
Art	Inter-tidal (AI)	All	38850	7350	34280	41630	3052	9
"	"	Surface	40280	2020	39210	41230	1015	3
"	"	Mid-depth	41310	830	40800	41630	446	3
"	"	Deep	34970	2010	34280	36290	1144	3
Art	Sub-tidal (AS)	All	40760	10270	35080	45350	3635	9
"	"	Surface	38600	2820	37030	39850	1437	3
"	"	Mid-depth	41360	10270	35080	45350	5505	3
"	"	Deep	42330	5560	38840	44400	3040	3
Ref	High (RH)	All	25430	8500	22250	30750	2959	9
"	"	Surface	22680	1250	22250	23500	708	3
"	"	Mid-depth	28590	4160	26590	30750	2085	3
"	"	Deep	25010	3380	23840	27220	1912	3
Ref	Inter-tidal (RI)	All	39160	14500	31920	46420	5660	7
"	"	Surface	34240	5760	31920	37680	3037	3
"	"	Mid-depth	40060	5450	37340	42790	3854	2
"	"	Deep	45620	1600	44820	46420	1131	2
Ref	Sub-tidal (RS)	All	51150	15810	44270	60080	4817	9
"	"	Surface	48440	550	48130	48680	280	3
"	"	Mid-depth	48300	7320	44270	51590	3716	3
"	"	Deep	56710	5980	54100	60080	3063	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

Table C'44

Statistics for Sediment Bulk Iron at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

			BULK IRON (μg/g)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	35740	30570	20780	51350	7474	49
Art	All	All	36170	26380	20780	47160	8184	24
Ref	All	All	35340	26330	25020	51350	6870	25
Art	High (AH)	All	24200	10150	20780	30930	3543	6
"	"	Surface	22820	3190	20780	23970	1768	3
"	"	Mid-depth	25570	9060	21870	30930	4750	3
"	"	Deep	---††	---††	---††	---††	---††	--††
Art	Inter-tidal (AI)	All	38780	9510	34770	44280	2884	9
"	"	Surface	37770	2730	36340	39070	1370	3
"	"	Mid-depth	41920	3960	40320	44280	2086	3
"	"	Deep	36660	3980	34770	38750	1997	3
Art	Sub-tidal (AS)	All	41530	17780	29380	47160	5370	9
"	"	Surface	41020	390	40810	41200	196	3
"	"	Mid-depth	39810	17780	29380	47160	9283	3
"	"	Deep	43750	7820	39100	46920	4116	3
Ref	High (RH)	All	33840	10980	29940	40920	3400	9
"	"	Surface	32810	4580	30600	35180	2294	3
"	"	Mid-depth	33430	4840	31040	35880	2420	3
"	"	Deep	35270	10980	29940	40920	5496	3
Ref	Inter-tidal (RI)	All	38460	18850	32500	51350	6636	8
"	"	Surface	42200	16520	34830	51350	8401	3
"	"	Mid-depth	38210	11260	33520	44780	5859	3
"	"	Deep	33200	1410	32500	33910	997	2
Ref	Sub-tidal (RS)	All	33910	23560	25020	48580	9393	8
"	"	Surface	47320	2520	46060	48580	1781	2
"	"	Mid-depth	32130	12070	26780	38850	6151	3
"	"	Deep	26750	4980	25020	30000	2816	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'45

Statistics for Sediment Bulk Lead at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			BULK LEAD (μg/g)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	53.1	71.0	9.6	80.6	17.6	52
Art	All	All	51.1	62.5	9.6	72.1	17.8	27
Ref	All	All	55.3	47.5	33.1	80.6	17.5	25
Art	High (AH)	All	29.7	45.7	9.6	53.3	13.1	9
"	"	Surface	20.6	22.7	9.6	32.3	11.4	3
"	"	Mid-depth	25.0	5.3	21.9	27.2	2.8	3
"	"	Deep	43.5	20.1	35.2	55.3	10.5	3
Art	Inter-tidal (AI)	All	58.7	17.0	48.5	65.5	6.4	9
"	"	Surface	61.1	4.2	59.2	63.4	2.1	3
"	"	Mid-depth	63.9	2.5	63.0	65.5	1.4	3
"	"	Deep	51.2	7.9	48.5	56.4	4.5	3
Art	Sub-tidal (AS)	All	64.8	15.9	56.2	72.1	5.6	9
"	"	Surface	64.8	7.9	61.8	69.7	4.3	3
"	"	Mid-depth	66.2	15.9	56.2	72.1	8.7	3
"	"	Deep	63.3	9.3	60.1	69.4	5.3	3
Ref	High (RH)	All	46.5	34.0	33.6	67.6	11.0	9
"	"	Surface	49.8	5.4	46.2	51.6	3.1	3
"	"	Mid-depth	54.5	25.7	41.9	67.6	12.9	3
"	"	Deep	35.1	4.0	33.6	37.6	2.2	3
Ref	Inter-tidal (RI)	All	41.0	26.3	33.1	59.4	9.0	7
"	"	Surface	46.3	24.8	34.6	59.4	12.5	3
"	"	Mid-depth	36.4	6.6	33.1	39.7	4.7	2
"	"	Deep	37.7	0.2	37.6	37.8	0.1	2
Ref	Sub-tidal (RS)	All	75.3	11.5	69.1	80.6	4.3	9
"	"	Surface	77.8	0.9	77.3	78.2	0.5	3
"	"	Mid-depth	78.3	3.6	77.0	80.6	2.0	3
"	"	Deep	69.7	1.6	69.1	70.7	0.8	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

Table C'46

Statistics for Sediment Bulk Lead at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

BULK LEAD (μg/g)

Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	56.4	58.7	28.1	86.8	17.2	48
Art	All	All	57.7	58.7	28.1	86.8	17.7	24
Ref	All	All	55.2	52.4	31.9	84.3	17.0	24
Art	High (AH)	All	33.8	18.3	38.1	46.4	7.0	6
"	"	Surface	33.0	8.5	29.1	37.6	4.3	3
"	"	Mid-depth	34.7	18.3	38.1	46.4	10.2	3
"	"	Deep	--††	--††	--††	--††	--††	--††
Art	Inter-tidal (AI)	All	64.1	29.4	51.2	80.6	8.9	9
"	"	Surface	61.2	13.8	54.6	68.4	6.9	3
"	"	Mid-depth	72.4	13.4	67.2	30.6	7.2	3
"	"	Deep	58.7	15.1	51.2	66.3	7.6	3
Art	Sub-tidal (AS)	All	67.2	49.0	37.8	86.8	14.8	9
"	"	Surface	63.8	15.9	53.6	69.5	8.8	3
"	"	Mid-depth	62.1	42.6	37.8	80.4	21.9	3
"	"	Deep	75.7	24.3	62.5	86.8	12.3	3
Ref	High (RH)	All	62.6	47.9	36.4	84.3	19.0	8
"	"	Surface	70.3	27.6	56.7	84.3	13.8	3
"	"	Mid-depth	81.3	3.0	79.8	82.8	2.1	2
"	"	Deep	42.5	10.2	36.4	46.6	5.4	3
Ref	Inter-tidal (RI)	All	53.5	32.7	38.4	71.1	11.6	8
"	"	Surface	60.9	18.7	52.4	71.1	9.5	3
"	"	Mid-depth	54.1	24.1	42.6	66.7	12.1	3
"	"	Deep	41.6	6.3	38.4	44.7	4.5	2
Ref	Sub-tidal (RS)	All	49.6	42.6	31.9	74.5	18.9	8
"	"	Surface	72.6	3.8	70.7	74.5	2.7	2
"	"	Mid-depth	49.8	32.6	38.6	71.2	18.5	3
"	"	Deep	34.0	5.0	31.9	36.9	2.6	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'47

Statistics for Interstitial Water Dissolved Manganese at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			DISSOLVED MANGANESE (mg/l)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	2.60	6.93	0.20	7.13	1.72	41
Art	All	All	3.82	5.94	1.19	7.13	1.37	20
Ref	All	All	1.44	3.44	0.20	3.64	1.12	21
Art	High (AH)	All	3.57	5.94	1.19	7.13	2.26	5
"	"	Surface	--††	--††	--††	--††	--††	--††
"	"	Mid-depth	5.14	3.98	3.15	7.13	2.81	2
"	"	Deep	2.53	2.91	1.19	4.10	1.47	3
Art	Inter-tidal (AI)	All	3.86	3.54	2.62	6.16	1.28	8
"	"	Surface	4.76	2.80	3.36	6.16	1.98	2
"	"	Mid-depth	3.94	2.82	2.62	5.44	1.42	3
"	"	Deep	3.18	0.92	2.69	3.61	0.46	3
Art	Sub-tidal (AS)	All	3.95	2.01	3.01	5.02	0.76	7
"	"	Surface	5.02	0.00	5.02	5.02	0.00	1
"	"	Mid-depth	3.75	1.88	3.01	4.89	1.00	3
"	"	Deep	3.80	0.53	3.52	4.05	0.27	3
Ref	High (RH)	All	0.40	0.42	0.20	0.62	0.16	7
"	"	Surface	0.47	0.00	0.47	0.47	0.00	1
"	"	Mid-depth	0.48	0.34	0.28	0.62	0.18	3
"	"	Deep	0.29	0.21	0.20	0.41	0.11	3
Ref	Inter-tidal (RI)	All	0.97	0.39	0.83	1.22	0.16	5
"	"	Surface	0.87	0.00	0.87	0.87	0.00	1
"	"	Mid-depth	0.86	0.05	0.83	0.88	0.04	2
"	"	Deep	1.12	0.19	1.03	1.22	0.13	2
Ref	Sub-tidal (RS)	All	2.51	2.39	1.25	3.64	0.86	9
"	"	Surface	3.14	1.23	2.41	3.64	0.64	3
"	"	Mid-depth	2.89	0.43	2.67	3.10	0.22	3
"	"	Deep	--††	--††	--††	--††	--††	--††

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'48

Statistics for Interstitial Water Dissolved Manganese at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

			DISSOLVED MANGANESE (mg/l)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	1.92	5.07	0.05	5.12	1.47	43
Art	All	All	2.84	4.20	0.34	4.54	1.22	18
Ref	All	All	1.27	5.07	0.05	5.12	1.28	25
Art	High (AH)	All	1.02	1.36	0.34	1.70	0.96	2
"	"	Surface	0.34	0.00	0.34	0.34	0.00	1
"	"	Mid-depth	1.70	0.00	1.70	1.70	0.00	1
"	"	Deep	--††	--††	--††	--††	--††	--††
Art	Inter-tidal (AI)	All	3.58	1.88	2.66	4.54	0.52	8
"	"	Surface	3.63	1.88	2.66	4.54	0.94	3
"	"	Mid-depth	3.43	0.04	3.41	3.45	0.03	2
"	"	Deep	3.64	0.23	3.49	3.72	0.13	3
Art	Sub-tidal (AS)	All	2.54	3.66	0.48	4.14	1.24	8
"	"	Surface	2.53	2.75	1.20	3.95	1.38	3
"	"	Mid-depth	3.43	1.42	2.72	4.14	1.00	2
"	"	Deep	1.96	2.38	0.48	2.86	1.29	3
Ref	High (RH)	All	0.33	0.52	0.05	0.57	0.16	9
"	"	Surface	0.32	0.45	0.05	0.50	0.24	3
"	"	Mid-depth	0.34	0.19	0.23	0.42	0.10	3
"	"	Deep	0.34	0.38	0.19	0.57	0.20	3
Ref	Inter-tidal (RI)	All	2.12	4.68	0.44	5.12	1.83	8
"	"	Surface	2.49	4.34	0.78	5.12	2.31	3
"	"	Mid-depth	2.13	4.22	0.44	4.66	2.23	3
"	"	Deep	1.54	1.86	0.61	2.47	1.32	2
Ref	Sub-tidal (RS)	All	1.48	1.30	0.96	2.26	0.53	8
"	"	Surface	1.74	0.27	1.61	1.88	0.19	2
"	"	Mid-depth	1.44	1.30	0.96	2.26	0.72	3
"	"	Deep	1.33	1.01	0.99	2.00	0.58	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'49

Statistics for Sediment Bulk Manganese at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			BULK MANGANESE (μg/g)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	628	1050	177	1230	369	52
Art	All	All	914	1030	200	1230	280	27
Ref	All	All	318	362	177	539	109	25
Art	High (AH)	All	616	830	200	1030	282	9
"	"	Surface	403	443	200	643	224	3
"	"	Mid-depth	500	101	454	555	51	3
"	"	Deep	944	229	801	1030	124	3
Art	Inter-tidal (AI)	All	1020	206	934	1140	84	9
"	"	Surface	951	31	934	965	16	3
"	"	Mid-depth	1120	60	1080	1140	32	3
"	"	Deep	984	112	938	1050	59	3
Art	Sub-tidal (AS)	All	1110	321	909	1230	118	9
"	"	Surface	1000	241	909	1150	129	3
"	"	Mid-depth	1150	180	1040	1220	96	3
"	"	Deep	1170	130	1100	1230	66	3
Ref	High (RH)	All	205	57	177	234	18	9
"	"	Surface	211	47	187	234	24	3
"	"	Mid-depth	190	30	177	207	15	3
"	"	Deep	214	12	208	220	6	3
Ref	Inter-tidal (RI)	All	303	75	269	344	24	7
"	"	Surface	286	38	269	307	19	3
"	"	Mid-depth	306	1	306	307	0	2
"	"	Deep	324	39	305	344	28	2
Ref	Sub-tidal (RS)	All	443	156	383	539	51	9
"	"	Surface	503	66	473	539	34	3
"	"	Mid-depth	412	44	396	440	24	3
"	"	Deep	415	57	383	440	29	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

Table C'50

Statistics for Sediment Bulk Manganese at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

BULK MANGANESE (μg/g)

Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	613	999	141	1140	336	48
Art	All	All	887	592	548	1140	180	24
Ref	All	All	340	792	141	933	207	24
Art	High (AH)	All	633	238	548	786	91	6
"	"	Surface	595.	124	548	672	67	3
"	"	Mid-depth	671.	215	571	786	108	3
"	"	Deep	--††	--††	--††	---††	--††	--††
Art	Inter-tidal (AI)	All	937	297	783	1080	102	9
"	"	Surface	826	101	783	884	52	3
"	"	Mid-depth	1030	96	984	1080	48	3
"	"	Deep	954	132	888	1020	66	3
Art	Sub-tidal (AS)	All	1010	355	785	1140	105	9
"	"	Surface	980	112	938	1050	61	3
"	"	Mid-depth	988	355	785	1140	183	3
"	"	Deep	1050	97	993	1090	50	3
Ref	High (RH)	All	201	164	141	305	54	8
"	"	Surface	231	140	165	305	70	3
"	"	Mid-depth	148	13	141	154	9	2
"	"	Deep	206	64	179	243	33	3
Ref	Inter-tidal (RI)	All	453	703	230	933	264	8
"	"	Surface	579	603	330	933	315	3
"	"	Mid-depth	458	504	285	789	287	3
"	"	Deep	256	53	230	283	37	2
Ref	Sub-tidal (RS)	All	366	506	231	737	174	8
"	"	Surface	618	237	500	737	168	2
"	"	Mid-depth	305	116	253	369	59	3
"	"	Deep	258	60	231	291	31	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'51

Statistics for Interstitial Water Dissolved Mercury at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			DISSOLVED MERCURY (μg/l)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	4.7	21.1	1.1	22.2	4.3	38
Art	All	All	5.6	20.7	1.5	22.2	5.5	18
Ref	All	All	4.0	9.7	1.1	10.8	2.7	20
Art	High (AH)	All	9.3	19.4	2.8	22.2	11.2	3
"	"	Surface	--††	--††	--††	--††	--††	--††
"	"	Mid-depth	12.5	19.4	2.8	22.2	13.8	2
"	"	Deep	3.0	0.0	3.0	3.0	0.0	1
Art	Inter-tidal (AI)	All	5.3	12.8	1.5	14.4	4.8	6
"	"	Surface	--††	--††	--††	--††	--††	--††
"	"	Mid-depth	6.4	12.0	2.3	14.4	6.9	3
"	"	Deep	4.3	5.5	1.5	7.0	2.8	3
Art	Sub-tidal (AS)	All	4.5	10.4	1.7	12.2	3.4	9
"	"	Surface	7.1	9.5	2.6	12.2	4.8	3
"	"	Mid-depth	3.9	4.3	2.3	6.5	2.3	3
"	"	Deep	2.4	1.6	1.7	3.3	0.8	3
Ref	High (RH)	All	4.7	8.3	1.8	10.1	2.9	6
"	"	Surface	--††	--††	--††	--††	--††	--††
"	"	Mid-depth	6.5	5.6	4.5	10.1	3.1	3
"	"	Deep	2.9	2.7	1.8	4.5	1.4	3
Ref	Inter-tidal (RI)	All	4.2	5.0	2.0	7.0	2.4	5
"	"	Surface	3.4	0.0	3.4	3.4	0.0	1
"	"	Mid-depth	6.8	0.2	6.7	7.0	0.2	2
"	"	Deep	2.1	0.1	2.0	2.1	0.1	2
Ref	Sub-tidal (RS)	All	3.4	9.7	1.1	10.8	3.0	9
"	"	Surface	2.2	1.0	1.7	2.7	0.5	3
"	"	Mid-depth	4.7	9.7	1.1	10.8	5.3	3
"	"	Deep	3.4	2.7	2.3	5.1	1.4	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'52

Statistics for Interstitial Water Dissolved Mercury at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

DISSOLVED MERCURY (μg/l)

Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	0.71	2.67	0.23	2.9	0.45	42
Art	All	All	0.82	2.67	0.23	2.9	0.64	17
Ref	All	All	0.64	1.07	0.26	1.33	0.25	25
Art	High (AH)	All	1.45	0.00	1.45	1.45	0.00	1
"	"	Surface	1.45	0.00	1.45	1.45	0.00	1
"	"	Mid-depth	--††	--††	--††	--††	--††	--††
"	"	Deep	--††	--††	--††	--††	--††	--††
Art	Inter-tidal (AI)	All	0.60	0.69	0.25	0.94	0.22	9
"	"	Surface	0.65	0.21	0.57	0.78	0.12	3
"	"	Mid-depth	0.66	0.44	0.50	0.94	0.25	3
"	"	Deep	0.49	0.60	0.25	0.85	0.32	3
Art	Sub-tidal (AS)	All	0.01	2.67	0.23	2.9	0.91	7
"	"	Surface	0.80	0.00	0.80	0.80	0.00	1
"	"	Mid-depth	1.66	2.18	0.72	2.9	1.12	3
"	"	Deep	0.42	0.48	0.23	0.70	0.25	3
Ref	High (RH)	All	0.53	0.47	0.28	0.75	0.19	9
"	"	Surface	0.71	0.07	0.67	0.74	0.04	3
"	"	Mid-depth	0.37	0.04	0.35	0.39	0.02	3
"	"	Deep	0.51	0.47	0.28	0.75	0.24	3
Ref	Inter-tidal (RI)	All	0.73	0.63	0.45	1.08	0.24	8
"	"	Surface	0.94	0.28	0.80	1.08	0.14	3
"	"	Mid-depth	0.55	0.21	0.46	0.67	0.11	3
"	"	Deep	0.67	0.44	0.45	0.89	0.31	2
Ref	Sub-tidal (RS)	All	0.66	1.07	0.26	1.33	0.31	8
"	"	Surface	0.48	0.32	0.26	0.59	0.19	3
"	"	Mid-depth	0.98	0.71	0.62	1.33	0.50	2
"	"	Deep	0.64	0.25	0.54	0.79	0.13	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'53

Statistics for Sediment Bulk Mercury at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			BULK MERCURY (ug/g)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	0.22	0.36	0.06	0.42	0.10	52
Art	All	All	0.23	0.32	0.06	0.38	0.09	27
Ref	All	All	0.21	0.34	0.09	0.42	0.12	25
Art	High (AH)	All	0.16	0.16	0.06	0.22	0.07	9
"	"	Surface	0.07	0.02	0.06	0.09	0.01	3
"	"	Mid-depth	0.20	0.04	0.18	0.22	0.02	3
"	"	Deep	0.20	0.01	0.20	0.21	0.01	3
Art	Inter-tidal (AI)	All	0.25	0.16	0.20	0.36	0.05	9
"	"	Surface	0.23	0.06	0.20	0.26	0.03	3
"	"	Mid-depth	0.28	0.14	0.22	0.36	0.07	3
"	"	Deep	0.25	0.09	0.21	0.30	0.04	3
Art	Sub-tidal (AS)	All	0.28	0.15	0.24	0.38	0.06	9
"	"	Surface	0.28	0.06	0.24	0.30	0.04	3
"	"	Mid-depth	0.28	0.12	0.24	0.36	0.06	3
"	"	Deep	0.29	0.15	0.24	0.38	0.08	3
Ref	High (RH)	All	0.15	0.16	0.08	0.24	0.05	9
"	"	Surface	0.18	0.12	0.13	0.24	0.06	3
"	"	Mid-depth	0.16	0.12	0.11	0.23	0.06	3
"	"	Deep	0.11	0.06	0.08	0.14	0.03	3
Ref	Inter-tidal (RI)	All	0.12	0.14	0.08	0.22	0.05	7
"	"	Surface	0.14	0.14	0.08	0.22	0.07	3
"	"	Mid-depth	0.10	0.02	0.08	0.10	0.01	2
"	"	Deep	0.10	0.02	0.09	0.10	0.01	2
Ref	Sub-tidal (RS)	All	0.35	0.12	0.30	0.42	0.05	9
"	"	Surface	0.33	0.03	0.32	0.35	0.02	3
"	"	Mid-depth	0.42	0.02	0.41	0.42	0.01	3
"	"	Deep	0.30	0.01	0.30	0.31	0.0	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

Table C'54

Statistics for Sediment Bulk Mercury at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

			BULK MERCURY (μg/g)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	0.23	1.31	0.06	1.37	0.18	49
Art	All	All	0.23	0.34	0.09	0.43	0.08	24
Ref	All	All	0.23	1.31	0.06	1.37	0.25	25
Art	High (AH)	All	0.14	0.14	0.09	0.24	0.06	6
"	"	Surface	0.17	0.14	0.10	0.24	0.07	3
"	"	Mid-depth	0.12	0.05	0.09	0.14	0.03	3
"	"	Deep	--††	--††	--††	--††	--††	--††
Art	Inter-tidal (AI)	All	0.24	0.14	0.20	0.33	0.05	9
"	"	Surface	0.26	0.11	0.22	0.32	0.06	3
"	"	Mid-depth	0.27	0.10	0.24	0.33	0.06	3
"	"	Deep	0.21	0.02	0.20	0.22	0.01	3
Art	Sub-tidal (AS)	All	0.28	0.23	0.20	0.43	0.07	9
"	"	Surface	0.25	0.11	0.20	0.31	0.05	3
"	"	Mid-depth	0.26	0.10	0.20	0.30	0.06	3
"	"	Deep	0.31	0.19	0.24	0.43	0.10	3
Ref	High (RH)	All	0.34	1.23	0.14	1.37	0.39	9
"	"	Surface	0.22	0.05	0.20	0.25	0.02	3
"	"	Mid-depth	0.22	0.12	0.15	0.28	0.06	3
"	"	Deep	0.57	1.23	0.14	1.37	0.70	3
Ref	Inter-tidal (RI)	All	0.20	0.23	0.07	0.30	0.09	8
"	"	Surface	0.23	0.07	0.20	0.27	0.04	3
"	"	Mid-depth	0.22	0.23	0.07	0.30	0.13	3
"	"	Deep	0.16	0.15	0.08	0.23	0.11	2
Ref	Sub-tidal (RS)	All	0.14	0.21	0.06	0.27	0.08	8
"	"	Surface	0.24	0.07	0.20	0.27	0.05	2
"	"	Mid-depth	0.14	0.12	0.09	0.21	0.06	3
"	"	Deep	0.07	0.02	0.06	0.08	0.01	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'55

Statistics for Sediment Bulk Nickel at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			BULK NICKEL (µg/g)					
Marsh*	**Location****	**Stratum†**	**Mean**	**Range**	**Min**	**Max**	**Std Dev**	**Number**
Both	All	All	32.8	33.6	7.4	41.0	8.4	52
Art	All	All	29.6	30.9	7.4	38.3	9.5	27
Ref	All	All	36.4	20.1	20.9	41.0	5.3	25
Art	High (AH)	All	18.1	26.5	7.4	33.9	7.7	9
"	"	Surface	12.8	9.8	7.4	17.2	5.0	3
"	"	Mid-depth	14.7	0.6	14.4	15.0	0.3	3
"	"	Deep	26.8	11.5	22.4	33.9	6.2	3
Art	Inter-tidal (AI)	All	34.6	4.1	32.8	36.9	1.6	9
"	"	Surface	34.3	3.1	32.9	36.0	1.6	3
"	"	Mid-depth	36.3	1.1	35.8	36.9	0.6	3
"	"	Deep	33.3	1.0	32.8	33.8	0.5	3
Art	Sub-tidal (AS)	All	36.0	5.6	32.7	38.2	2.5	9
"	"	Surface	35.0	4.7	32.7	37.4	2.4	3
"	"	Mid-depth	36.3	5.4	32.9	38.3	3.0	3
"	"	Deep	36.5	5.0	33.2	38.2	2.9	3
Ref	High (RH)	All	31.4	16.3	20.9	37.2	5.9	9
"	"	Surface	24.0	6.1	20.9	27.0	3.1	3
"	"	Mid-depth	36.3	1.8	35.4	37.2	0.9	3
"	"	Deep	33.9	1.0	33.4	34.4	0.5	3
Ref	Inter-tidal (RI)	All	39.0	4.7	36.2	40.9	1.9	7
"	"	Surface	37.2	2.7	36.2	38.9	1.5	3
"	"	Mid-depth	40.6	0.7	40.2	40.9	0.5	2
"	"	Deep	40.0	1.6	39.2	40.8	1.1	2
Ref	Sub-tidal (RS)	All	39.4	5.4	35.6	41.0	1.7	9
"	"	Surface	40.7	0.8	40.2	41.0	0.4	3
"	"	Mid-depth	37.9	4.5	35.6	40.1	2.3	3
"	"	Deep	39.5	0.5	39.2	39.7	0.3	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

Table C'56

Statistics for Sediment Bulk Nickel at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

BULK NICKEL (μg/g)								
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	37.6	29.1	18.5	47.6	8.5	48
Art	All	All	32.4	28.6	18.5	47.1	9.1	24
Ref	All	All	42.8	10.8	36.8	47.6	3.2	24
Art	High (AH)	All	19.7	5.3	18.5	23.8	2.1	6
"	"	Surface	18.7	0.6	18.5	19.1	0.3	3
"	"	Mid-depth	20.6	5.2	18.6	23.8	2.8	3
"	"	Deep	--††	--††	--††	--††	--††	--††
Art	Inter-tidal (AI)	All	34.5	12.3	30.1	42.4	4.3	9
"	"	Surface	32.1	3.0	31.0	34.0	1.7	3
"	"	Mid-depth	39.1	5.6	36.8	42.4	2.9	3
"	"	Deep	32.4	6.7	30.1	36.8	3.8	3
Art	Sub-tidal (AS)	All	38.9	23.0	24.1	47.1	6.8	9
"	"	Surface	38.2	1.1	37.7	38.8	0.6	3
"	"	Mid-depth	36.2	20.8	24.1	44.9	10.8	3
"	"	Deep	42.4	11.9	35.2	47.1	6.2	3
Ref	High (RH)	All	40.6	9.8	36.8	46.6	3.6	8
"	"	Surface	38.8	3.0	37.4	40.4	1.5	3
"	"	Mid-depth	38.6	3.7	36.8	40.5	2.6	2
"	"	Deep	43.8	7.3	39.3	46.6	3.9	3
Ref	Inter-tidal (RI)	All	44.0	3.8	41.9	45.7	1.4	8
"	"	Surface	44.3	1.2	43.8	45.0	0.6	3
"	"	Mid-depth	43.9	3.1	42.2	45.3	1.6	3
"	"	Deep	43.8	3.8	41.9	45.7	2.7	2
Ref	Sub-tidal (RS)	All	43.6	9.4	38.2	47.6	3.3	8
"	"	Surface	44.9	2.2	43.8	46.0	1.6	2
"	"	Mid-depth	44.6	2.5	43.5	46.0	1.3	3
"	"	Deep	41.7	9.4	38.2	47.6	5.1	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'57

Statistics for Interstitial Water Dissolved Zinc at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			DISSOLVED ZINC (mg/l)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	0.069	0.282	0.003	0.285	0.058	41
Art	All	All	0.063	0.282	0.003	0.285	0.069	20
Ref	All	All	0.075	0.168	0.016	0.184	0.045	21
Art	High (AH)	All	0.112	0.260	0.025	0.285	0.120	5
"	"	Surface	---††	---††	---††	---††	---††	--††
"	"	Mid-depth	0.109	0.167	0.025	0.192	0.118	2
"	"	Deep	0.115	0.260	0.025	0.285	0.148	3
Art	Inter-tidal (AI)	All	0.051	0.106	0.003	0.109	0.040	8
"	"	Surface	0.084	0.049	0.060	0.109	0.035	2
"	"	Mid-depth	0.032	0.084	0.003	0.087	0.047	3
"	"	Deep	0.048	0.070	0.012	0.082	0.035	3
Art	Sub-tidal (AS)	All	0.041	0.084	0.012	0.096	0.031	7
"	"	Surface	0.025	0.000	0.025	0.025	0.000	1
"	"	Mid-depth	0.044	0.049	0.025	0.074	0.026	3
"	"	Deep	0.043	0.084	0.012	0.096	0.046	3
Ref	High (RH)	All	0.079	0.079	0.043	0.122	0.031	7
"	"	Surface	0.047	0.000	0.047	0.047	0.000	1
"	"	Mid-depth	0.087	0.066	0.056	0.122	0.033	3
"	"	Deep	0.082	0.061	0.043	0.104	0.034	3
Ref	Inter-tidal (RI)	All	0.059	0.066	0.025	0.091	0.030	5
"	"	Surface	0.091	0.000	0.091	0.091	0.000	1
"	"	Mid-depth	0.045	0.004	0.043	0.047	0.003	2
"	"	Deep	0.058	0.066	0.025	0.091	0.047	2
Ref	Sub-tidal (RS)	All	0.081	0.168	0.016	0.184	0.061	9
"	"	Surface	0.065	0.106	0.025	0.131	0.050	3
"	"	Mid-depth	0.121	0.124	0.060	0.184	0.062	3
"	"	Deep	0.059	0.115	0.016	0.131	0.063	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'58

Statistics for Interstitial Water Dissolved Zinc at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

DISSOLVED ZINC (mg/l)

Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	0.054	0.130	0.018	0.148	0.033	43
Art	All	All	0.056	0.130	0.018	0.148	0.040	18
Ref	All	All	0.053	0.130	0.018	0.148	0.028	25
Art	High (AH)	All	0.034	0.018	0.025	0.043	0.013	2
"	"	Surface	0.025	0.000	0.025	0.025	0.000	1
"	"	Mid-depth	0.043	0.000	0.043	0.043	0.000	1
"	"	Deep	---††	---††	---††	---††	---††	--††
Art	Inter-tidal (AI)	All	0.048	0.105	0.018	0.123	0.038	8
"	"	Surface	0.020	0.007	0.018	0.025	0.004	3
"	"	Mid-depth	0.029	0.014	0.022	0.036	0.010	2
"	"	Deep	0.088	0.058	0.065	0.123	0.031	3
Art	Sub-tidal (AS)	All	0.069	0.126	0.022	0.148	0.044	8
"	"	Surface	0.075	0.071	0.033	0.104	0.037	3
"	"	Mid-depth	0.095	0.107	0.041	0.148	0.076	2
"	"	Deep	0.047	0.063	0.022	0.085	0.034	3
Ref	High (RH)	All	0.053	0.055	0.026	0.081	0.021	9
"	"	Surface	0.045	0.041	0.026	0.067	0.021	3
"	"	Mid-depth	0.062	0.040	0.041	0.081	0.020	3
"	"	Deep	0.053	0.048	0.033	0.081	0.025	3
Ref	Inter-tidal (RI)	All	0.060	0.111	0.037	0.148	0.037	8
"	"	Surface	0.051	0.026	0.037	0.063	0.013	3
"	"	Mid-depth	0.080	0.111	0.037	0.148	0.059	3
"	"	Deep	0.045	0.015	0.037	0.052	0.011	2
Ref	Sub-tidal (RS)	All	0.045	0.082	0.018	0.100	0.027	8
"	"	Surface	0.039	0.034	0.022	0.056	0.024	2
"	"	Mid-depth	0.044	0.037	0.026	0.063	0.019	3
"	"	Deep	0.050	0.082	0.018	0.100	0.044	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

†† No data for this specific depth interval.

Table C'59

Statistics for Sediment Bulk Zinc at the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 1976

			BULK ZINC (ug/g)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	202	521	43	564	108	52
Art	All	All	182	206	43	249	60	27
Ref	All	All	224	463	101	564	142	25
Art	High (AH)	All	111	164	43	207	48	9
"	"	Surface	78	70	43	113	35	3
"	"	Mid-depth	89	18	80	98	9	3
"	"	Deep	166	63	144	207	36	3
Art	Inter-tidal (AI)	All	211	53	179	232	17	9
"	"	Surface	214	9	209	218	5	3
"	"	Mid-depth	227	11	221	232	6	3
"	"	Deep	193	30	179	209	15	3
Art	Sub-tidal (AS)	All	224	75	174	249	24	9
"	"	Surface	230	28	218	246	14	3
"	"	Mid-depth	235	38	211	249	21	3
"	"	Deep	208	64	174	238	32	3
Ref	High (RH)	All	131	67	101	168	27	9
"	"	Surface	162	16	152	168	9	3
"	"	Mid-depth	130	29	112	141	16	3
"	"	Deep	102	2	101	103	1	3
Ref	Inter-tidal (RI)	All	137	118	112	230	42	7
"	"	Surface	161	108	122	230	60	3
"	"	Mid-depth	122	11	117	128	8	2
"	"	Deep	115	6	112	118	4	2
Ref	Sub-tidal (RS)	All	385	349	215	564	111	9
"	"	Surface	352	85	313	398	43	3
"	"	Mid-depth	512	128	436	564	67	3
"	"	Deep	292	131	215	346	69	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

Table C'60

Statistics for Sediment Bulk Zinc at the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 1977

			BULK ZINC (µg/g)					
Marsh*	Location**	Stratum†	Mean	Range	Min	Max	Std Dev	Number
Both	All	All	188	277	105	382	61	49
Art	All	All	190	169	108	277	50	24
Ref	All	All	186	277	105	382	72	25
Art	High (AH)	All	122	47	108	155	17	6
"	"	Surface	117	18	108	126	9	3
"	"	Mid-depth	127	43	112	155	24	3
"	"	Deep						
Art	Inter-tidal (AI)	All	207	78	176	254	24	9
"	"	Surface	198	39	178	217	20	3
"	"	Mid-depth	231	35	219	254	20	3
"	"	Deep	190	27	176	203	14	3
Art	Sub-tidal (AS)	All	219	137	140	277	39	9
"	"	Surface	231	15	221	236	8	3
"	"	Mid-depth	203	95	140	235	54	3
"	"	Deep	225	94	183	277	48	3
Ref	High (RH)	All	194	258	124	382	78	9
"	"	Surface	270	193	189	282	100	3
"	"	Mid-depth	169	31	153	184	16	3
"	"	Deep	142	29	124	153	16	3
Ref	Inter-tidal (RI)	All	179	134	118	252	50	8
"	"	Surface	212	65	187	252	35	3
"	"	Mid-depth	184	106	129	235	53	3
"	"	Deep	123	10	118	128	7	2
Ref	Sub-tidal (RS)	All	186	209	105	314	89	8
"	"	Surface	283	62	252	314	44	2
"	"	Mid-depth	192	180	124	304	98	3
"	"	Deep	114	25	105	130	14	3

* Marsh refers to either Art = James River Artificial Habitat Development Site, Ref = natural reference marsh, or Both = both marshes (9 cores collected at each marsh during each season).

** Location refers to sampling area within each marsh (3 cores at each location), where High (AH) or (RH) = high marsh, while others are self-explanatory. See Figures 2 and 3 for locations.

† Stratum refers to the depth interval (or specific horizon) within each core, where All = all horizons (0 to 50 cm), Surface = 0 to 10 cm, Mid-depth = 11 to 24 cm, or Deep = 25 to 50 cm.

Table C'61

Tidal Statistics for Conductivity at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

CONDUCTIVITY (mmho/cm)

		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Low Slack	mean	0.186		0.161	0.161
	range	0.047		0.019	0.019
	min.	0.166		0.153	0.155
	max.	0.213		0.172	0.174
	std. dev.	0.019		0.006	0.007
	number	6		7	7
Flood	mean	0.170	0.173	0.162	0.171
	range	0.058	0.041	0.014	0.040
	min.	0.157	0.165	0.153	0.162
	max.	0.215	0.206	0.167	0.202
	std. dev.	0.017	0.012	0.005	0.011
	number	10	10	10	10
High Slack	mean	0.165	0.165	0.166	0.167
	range	0.016	0.010	0.014	0.006
	min.	0.160	0.158	0.162	0.163
	max.	0.176	0.168	0.172	0.169
	std. dev.	0.007	0.004	0.004	0.002
	number	5	5	10	10
Ebb	mean	0.175	0.169	0.166	0.166
	range	0.033	0.035	0.028	0.014
	min.	0.159	0.158	0.159	0.161
	max.	0.192	0.193	0.187	0.175
	std. dev.	0.010	0.009	0.007	0.003
	number	13	13	15	14
Pore Water Drainage	mean	0.200			
	range	0.021			
	min.	0.192			
	max.	0.213			
	std. dev.	0.007			
	number	7			
All Samples	mean	0.178	0.171	0.164	0.167
	range	0.058	0.048	0.034	0.047
	min.	0.157	0.158	0.153	0.155
	max.	0.215	0.206	0.187	0.202
	std. dev.	0.017	0.011	0.006	0.007
	number	44	32	48	47

Table C'62

Tidal Statistics for Conductivity at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

CONDUCTIVITY (mmho/cm)

		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Flood	mean	0.154	0.201	0.103	0.109
	range	0.096	0.282	0.040	0.028
	min.	0.134	0.139	0.073	0.097
	max.	0.230	0.421	0.113	0.125
	std. dev.	0.025	0.093	0.011	0.007
	number	17	16	20	22
High Slack	mean	0.140	0.143	0.114	0.115
	range	0.012	0.007	0.010	0.011
	min.	0.133	0.139	0.108	0.110
	max.	0.145	0.146	0.118	0.121
	std. dev.	0.006	0.005	0.004	0.006
	number	5	2	5	3
Ebb	mean	0.197	0.205	0.106	0.107
	range	0.362	0.195	0.018	0.024
	min.	0.127	0.138	0.098	0.097
	max.	0.489	0.333	0.116	0.121
	std. dev.	0.100	0.084	0.006	0.006
	number	14	8	17	18
Low Slack	mean	0.157		0.089	0.098
	range	0.071		0.024	0.032
	min.	0.111		0.075	0.078
	max.	0.182		0.099	0.110
	std. dev.	0.032		0.010	0.014
	number	4		4	5
Pore Water Drainage	mean	0.157			
	range	0.048			
	min.	0.135			
	max.	0.183			
	std. dev.	0.020			
	number	5			
Preprecipitational Ebb	mean		0.141	0.112	0.122
	range		0.023	0.005	0.007
	min.		0.131	0.110	0.118
	max.		0.154	0.115	0.125
	std. dev.		0.012	0.002	0.004
	number		4	4	3
All Samples	mean	0.170	0.192	0.104	0.109
	range	0.378	0.290	0.045	0.047
	min.	0.111	0.131	0.073	0.078
	max.	0.489	0.421	0.118	0.125
	std. dev.	0.066	0.082	0.010	0.009
	number	48	32	53	52

Table C'63

Tidal Statistics for Water Temperature at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

WATER TEMPERATURE (°C)

Tidal Stage		Artificial Marsh Pipe	Artificial Marsh Breach	Natural Marsh Large channel	Natural Marsh Small channel
Low Slack	mean	25.2		26.6	26.6
	range	5.6		2.9	2.9
	min.	22.0		25.0	25.2
	max.	27.6		27.9	28.1
	std. dev.	2.2		1.3	1.2
	number	6		7	6
Flood	mean	26.0	26.2	26.6	26.2
	range	3.9	2.5	2.0	1.9
	min.	24.4	24.6	25.4	25.1
	max.	28.3	27.1	27.4	27.0
	std. dev.	1.1	0.9	0.8	0.7
	number	10	10	10	10
High Slack	mean	26.9	26.3	26.8	26.6
	range	4.3	2.6	1.7	1.2
	min.	25.0	25.2	26.3	26.0
	max.	29.3	27.8	28.0	27.2
	std. dev.	2.1	1.1	0.5	0.4
	number	5	5	10	10
Ebb	mean	26.0	26.3	26.9	26.5
	range	6.2	6.2	4.4	3.4
	min.	22.4	22.8	25.2	24.8
	max.	28.6	29.0	29.6	28.2
	std. dev.	2.1	1.9	1.4	1.2
	number	14	13	15	14
Pore Water Drainage	mean	24.5			
	range	6.7			
	min.	21.7			
	max.	28.4			
	std. dev.	2.8			
	number	8			
All Samples	mean	25.8	26.2	26.8	26.5
	range	7.6	6.2	4.6	3.4
	min.	21.7	22.8	25.0	24.8
	max.	29.3	29.0	29.6	28.2
	std. dev.	2.1	1.5	1.0	0.9
	number	46	33	48	46

Table C'64

Tidal Statistics for Water Temperature at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

WATER TEMPERATURE (°C)

		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Flood	mean	1.7	1.7	0.7	0.7
	range	3.6	3.3	2.2	2.0
	min.	-0.1	0.1	-0.5	0.0
	max.	3.5	3.4	1.7	2.0
	std. dev.	1.4	0.9	0.6	0.6
	number	17	16	20	22
High Slack	mean	0.7	1.4	0.8	1.0
	range	1.8	1.4	1.1	0.8
	min.	0.2	0.7	0.4	0.6
	max.	2.0	2.1	1.5	1.4
	std. dev.	0.7	1.0	0.4	0.4
	number	5	2	5	3
Ebb	mean	0.3	0.3	0.5	0.4
	range	1.8	1.8	0.8	1.0
	min.	-0.4	-0.2	0.2	0.0
	max.	1.4	1.6	1.0	1.0
	std. dev.	0.5	0.6	0.2	0.3
	number	13	7	17	19
Low Slack	mean	1.2		0.4	0.4
	range	4.4		0.4	1.0
	min.	-0.2		0.2	0.0
	max.	4.2		0.6	1.0
	std. dev.	2.0		0.2	0.4
	number	4		4	5
Pore Water Drainage	mean	0.7			
	range	3.9			
	min.	-0.3			
	max.	3.6			
	std. dev.	1.6			
	number	5			
Preprecipitational Ebb	mean		0.8	1.1	0.6
	range		0.8	1.2	0.1
	min.		0.4	0.6	0.6
	max.		1.2	1.8	0.7
	std. dev.		0.3	0.5	0.1
	number		4	4	3
All Samples	mean	1.1	1.2	0.7	0.6
	range	4.6	3.6	2.3	2.0
	min.	-0.4	-0.2	-0.5	0.0
	max.	4.2	3.4	1.8	2.0
	std. dev.	1.4	1.0	0.5	0.5
	number	47	34	53	53

Table C'65

Tidal Statistics for pH at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

pH

		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Low Slack	mean	7.17		7.04	6.99
	range	0.65		0.50	0.60
	min.	6.80		6.85	6.70
	max.	7.45		7.35	7.30
	std. dev.	0.28		0.19	0.21
	number	6		7	7
Flood	mean	7.24	7.49	7.53	7.65
	range	0.70	0.80	0.75	1.00
	min.	6.90	7.30	7.20	7.15
	max.	7.60	8.10	7.95	8.15
	std. dev.	0.24	0.26	0.25	0.31
	number	10	9	8	9
High Slack	mean	7.38	7.46	7.59	7.41
	range	0.70	0.95	0.70	0.50
	min.	7.00	7.15	7.25	7.10
	max.	7.70	8.10	7.95	7.60
	std. dev.	0.33	0.38	0.21	0.16
	number	5	5	9	9
Ebb	mean	6.95	7.02	7.19	7.07
	range	0.85	0.95	1.55	1.95
	min.	6.75	6.75	6.70	6.60
	max.	7.60	7.70	8.25	8.55
	std. dev.	0.21	0.27	0.52	0.53
	number	14	13	15	12
Pore Water Drainage	mean	6.97			
	range	0.25			
	min.	6.90			
	max.	7.15			
	std. dev.	0.09			
	number	8			
All Samples	mean	7.11	7.28	7.34	7.30
	range	0.95	1.35	1.55	1.95
	min.	6.75	6.75	6.70	6.60
	max.	7.70	8.10	8.25	8.55
	std. dev.	0.27	0.35	0.40	0.42
	number	45	30	44	41

Table C'66

Tidal Statistics for pH at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

		pH			
		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Flood	mean	7.50	7.43	7.94	7.97
	range	0.84	0.82	0.75	0.65
	min.	7.16	7.08	7.65	7.75
	max.	8.00	7.90	8.40	8.40
	std. dev.	0.27	0.26	0.20	0.18
	number	14	13	20	22
High Slack	mean	7.40	7.71	8.05	8.20
	range	0.37	0.38	0.80	0.70
	min.	7.19	7.52	7.70	7.75
	max.	7.56	7.90	8.50	8.45
	std. dev.	0.16	0.27	0.39	0.39
	number	5	2	5	3
Ebb	mean	7.35	7.42	8.08	8.01
	range	1.02	0.23	0.90	0.90
	min.	6.88	7.28	7.65	7.65
	max.	7.90	7.51	8.55	8.55
	std. dev.	0.24	0.10	0.29	0.29
	number	14	8	17	19
Low Slack	mean	7.36		8.24	8.14
	range	0.50		0.50	0.30
	min.	7.10		7.90	7.95
	max.	7.60		8.40	8.25
	std. dev.	0.21		0.23	0.12
	number	4		4	5
Pore Water Drainage	mean	7.47			
	range	0.80			
	min.	7.10			
	max.	7.90			
	std. dev.	0.30			
	number	5			
Preprecipitational Ebb	mean		7.06	7.75	7.68
	range		0.37	0.00	0.20
	min.		6.88	7.75	7.55
	max.		7.25	7.75	7.75
	std. dev.		0.16	0.00	0.16
	number		4	4	3
All Samples	mean	7.41	7.39	8.00	7.99
	range	1.12	1.02	0.90	1.00
	min.	6.88	6.88	7.65	7.55
	max.	8.00	7.90	8.55	8.55
	std. dev.	0.25	0.25	0.26	0.25
	number	43	28	53	53

Table C'67

Tidal Statistics for Dissolved Oxygen at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

DISSOLVED OXYGEN (mg/1)

		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Low Slack	mean	6.08		7.46	6.55
	range	2.56		5.19	5.68
	min.	4.95		4.88	3.02
	max.	7.51		10.07	8.70
	std. dev.	1.14		2.16	2.09
	number	4		7	6
Flood	mean	6.15	6.38	7.34	7.37
	range	2.25	2.09	2.60	1.79
	min.	4.69	5.15	6.13	6.21
	max.	6.94	7.24	8.73	8.00
	std. dev.	0.85	0.64	0.92	0.66
	number	8	10	7	8
High Slack	mean	6.43	6.16	7.08	6.88
	range	2.18	2.24	3.40	3.59
	min.	5.33	5.37	5.10	4.99
	max.	7.51	7.61	8.50	8.58
	std. dev.	0.98	0.86	0.97	1.05
	number	4	5	10	10
Ebb	mean	4.46	5.16	6.57	6.35
	range	3.12	2.92	5.17	6.31
	min.	3.05	3.80	4.33	3.26
	max.	6.17	6.72	9.50	9.57
	std. dev.	0.99	0.87	1.86	2.18
	number	13	12	13	13
Pore Water Drainage	mean	4.95			
	range	1.17			
	min.	4.24			
	max.	5.41			
	std. dev.	0.47			
	number	7			
All Samples	mean	5.48	6.00	7.10	6.77
	range	5.40	4.05	5.74	6.55
	min.	3.05	3.80	4.33	3.02
	max.	8.45	7.85	10.07	9.57
	std. dev.	1.29	1.10	1.51	1.56
	number	39	31	42	42

Table C'68

Tidal Statistics for Dissolved Oxygen at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

DISSOLVED OXYGEN (mg/l)

		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Flood	mean	11.43	11.62	12.36	12.26
	range	2.77	1.66	2.33	3.18
	min.	9.88	10.95	10.74	9.67
	max.	12.65	12.61	13.07	12.85
	std. dev.	0.74	0.58	0.55	0.73
	number	17	13	15	16
High Slack	mean	11.64	10.74	12.42	12.32
	range	1.37	0.29	0.73	1.06
	min.	10.73	10.59	12.11	11.88
	max.	12.10	10.88	12.84	12.94
	std. dev.	0.56	0.20	0.30	0.55
	number	5	2	4	3
Ebb	mean	10.99	11.04	12.08	12.32
	range	3.56	2.17	2.02	1.24
	min.	8.52	9.76	10.63	11.49
	max	12.08	11.93	12.65	12.73
	std. dev.	0.90	0.74	0.55	0.33
	number	13	8	15	13
Low Slack	mean	11.67		12.33	12.25
	range	1.39		0.10	1.04
	min.	11.10		12.30	11.78
	max.	12.49		12.40	12.82
	std. dev.	0.73		0.05	0.38
	number	3		4	5
Pore Water Drainage	mean	11.74			
	range	0.96			
	min.	11.22			
	max.	12.18			
	std. dev.	0.39			
	number	5			
Preprecipitational Ebb	mean		12.07	12.13	11.70
	range		0.14	0.35	0.96
	min.		12.02	11.97	11.11
	max.		12.16	12.32	12.07
	std. dev.		0.07	0.14	0.52
	number		4	4	3
All Samples	mean	11.40	11.50	12.25	12.34
	range	4.13	2.85	2.44	6.67
	min.	8.52	9.76	10.63	9.67
	max.	12.65	12.61	13.07	16.34
	std. dev.	0.79	0.68	0.47	0.83
	number	46	30	45	43

Table C'69

Tidal Statistics for Oxygen Saturation at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

OXYGEN SATURATION (%)

Tidal Stage		Artificial Marsh Pipe	Artificial Marsh Breach	Natural Marsh Large channel	Natural Marsh Small channel
Low Slack	mean	73		96	82
	range	34		68	72
	min.	57		58	36
	max.	91		126	108
	std. dev.	14		29	30
	number	4		6	5
Flood	mean	75	78	90	90
	range	29	28	33	24
	min.	57	61	76	74
	max.	86	90	109	98
	std. dev.	11	9	12	9
	number	8	10	7	8
High Slack	mean	80	75	87	84
	range	32	31	44	46
	min.	64	64	63	60
	max.	96	95	107	106
	std. dev.	15	12	12	13
	number	4	5	10	10
Ebb	mean	55	63	81	78
	range	41	41	68	77
	min.	36	44	52	39
	max.	78	85	120	116
	std. dev.	14	12	24	28
	number	13	12	13	13
Pore Water Drainage	mean	59			
	range	19			
	min.	49			
	max.	68			
	std. dev.	8			
	number	7			
All Samples	mean	67	73	88	83
	range	72	54	74	80
	min.	36	44	52	36
	max.	108	98	126	116
	std. dev.	17	15	20	20
	number	39	31	41	41

Table C'70

Tidal Statistics for Oxygen Saturation at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

OXYGEN SATURATION (%)

		Artificial Marsh		Natural Marsh	
Tidal Stage		**Pipe**	**Breach**	**Large channel**	**Small channel**
Flood	mean	83	85	87	86
	range	23	16	17	24
	min.	70	77	76	67
	max.	93	93	93	91
	std. dev.	7	6	4	6
	number	17	13	15	16
High Slack	mean	82	78	88	88
	range	13	5	5	9
	min.	76	75	87	84
	max.	89	80	92	92
	std. dev.	5	4	2	4
	number	5	2	4	3
Ebb	mean	78	77	85	86
	range	14	17	15	9
	min.	72	68	75	81
	max.	86	84	90	90
	std. dev.	4	6	4	3
	number	12	7	15	15
Low Slack	mean	81		87	86
	range	11		1	8
	min.	77		86	83
	max.	87		87	92
	std. dev.	6		0	3
	number	3		4	5
Pore Water Drainage	mean	83			
	range	6			
	min.	80			
	max.	86			
	std. dev.	3			
	number	5			
Preprecipitational Ebb	mean		86	87	83
	range		2	3	7
	min.		85	86	85
	max.		87	88	85
	std. dev.		1	1	4
	number		4	4	3
All Samples	mean	82	83	87	87
	range	27	26	18	48
	min.	70	68	75	67
	max.	97	94	93	115
	std. dev.	6	7	4	6
	number	45	28	45	43

Table C'71

Tidal Statistics for Alkalinity at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977*

ALKALINITY (meq/l)

		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Flood	mean	0.48	0.48	0.40	0.43
	range	1.10	0.53	0.52	0.42
	min.	0.01	0.25	0.05	0.15
	max.	1.11	0.78	0.57	0.57
	std. dev.	0.23	0.15	0.12	0.10
	number	17	16	19	21
High Slack	mean	0.48	0.50	0.42	0.28
	range	0.24	0.19	0.15	0.08
	min.	0.37	0.40	0.33	0.25
	max.	0.61	0.59	0.48	0.33
	std. dev.	0.12	0.13	0.07	0.04
	number	5	2	5	3
Ebb	mean	0.53	0.50	0.40	0.36
	range	0.63	0.36	0.44	0.39
	min.	0.26	0.34	0.20	0.19
	max.	0.89	0.70	0.64	0.58
	std. dev.	0.15	0.15	0.13	0.12
	number	14	8	17	19
Low Slack	mean	0.45		0.22	0.43
	range	0.28		0.27	0.56
	min.	0.34		0.07	0.27
	max.	0.62		0.34	0.83
	std. dev.	0.15		0.11	0.23
	number	3		4	5
Pore Water Drainage	mean	0.49			
	range	0.41			
	min.	0.33			
	max.	0.74			
	std. dev.	0.16			
	number	5			
Preprecipitational Ebb	mean		0.57	0.49	0.51
	range		0.10	0.20	0.04
	min.		0.51	0.36	0.49
	max.		0.61	0.56	0.53
	std. dev.		0.04	0.09	0.03
	number		4	4	2
All Samples	mean	0.49	0.49	0.39	0.40
	range	1.10	0.53	0.59	0.68
	min.	0.01	0.25	0.05	0.15
	max.	1.11	0.78	0.64	0.83
	std. dev.	0.18	0.13	0.13	0.13
	number	47	33	52	51

* Data for the August 1976 period was not reported because of errors in the analysis

Table C'72

Tidal Statistics for Suspended Solids at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

SUSPENDED SOLIDS (mg/l)

		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Low Slack	mean	247		24	19
	range	661		31	6
	min.	38		4	15
	max.	699		35	21
	std. dev.	289		10	2
	number	6		8	6
Flood	mean	60	43	29	27
	range	90	40	26	24
	min.	31	28	16	17
	max.	121	68	42	41
	std. dev.	30	14	9	9
	number	10	8	7	7
High Slack	mean	43	31	29	23
	range	35	14	91	35
	min.	29	22	2	2
	max.	64	36	93	37
	std. dev.	15	6	26	10
	number	4	5	10	10
Ebb	mean	78	41	24	23
	range	238	63	54	27
	min.	28	18	12	9
	max.	266	81	66	36
	std. dev.	77	21	13	8
	number	13	11	14	12
Pore Water Drainage	mean	178			
	range	428			
	min.	29			
	max.	457			
	std. dev.	160			
	number	8			
All Samples	mean	117	37	26	23
	range	671	71	91	39
	min.	28	10	2	2
	max.	699	81	93	41
	std. dev.	145	17	15	8
	number	44	28	44	40

Table C'73

Tidal Statistics for Suspended Solids at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

		SUSPENDED SOLIDS (mg/l)			
		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Flood	mean	60	37	28	34
	range	257	70	74	109
	min.	17	9	7	11
	max.	274	79	81	120
	std. dev.	67	22	18	28
	number	16	15	20	21
High Slack	mean	27	25	17	29
	range	26	9	8	25
	min.	17	20	13	19
	max.	43	29	21	44
	std. dev.	11	6	4	13
	number	4	2	3	3
Ebb	mean	23	22	20	26
	range	39	25	17	103
	min.	8	8	14	13
	max.	47	33	31	116
	std. dev.	10	8	4	24
	number	13	8	17	17
Low Slack	mean	63		15	16
	range	109		5	9
	min.	22		12	11
	max.	131		17	20
	std. dev.	47		3	5
	number	4		3	4
Pore Water Drainage	mean	121			
	range	261			
	min.	32			
	max.	293			
	std. dev.	107			
	number	5			
Preprecipitational Ebb	mean		22	39	21
	range		18	62	11
	min.		16	16	16
	max.		34	78	27
	std. dev.		8	21	6
	number		4	4	3
All Samples	mean	69	31	24	29
	range	731	87	74	109
	min.	8	8	7	11
	max.	739	95	81	120
	std. dev.	119	21	15	24
	number	45	31	48	49

Table C'74

Tidal Statistics for Turbidity at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

TURBIDITY (FTU)

		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Low Slack	mean	59		16	15
	range	87		3	6
	min.	23		14	12
	max.	110		17	18
	std. dev.	41		1	2
	number	6		7	7
Flood	mean	35	22	19	18
	range	50	18	9	11
	min.	17	14	12	11
	max.	67	32	21	22
	std. dev.	17	6	3	3
	number	10	10	9	10
High Slack	mean	24	19	16	17
	range	13	6	5	8
	min.	14	16	13	13
	max.	27	22	18	21
	std. dev.	6	3	2	2
	number	5	5	10	10
Ebb	mean	33	26	14	16
	range	63	28	7	10
	min.	14	16	10	12
	max.	77	44	17	22
	std. dev.	17	7	2	3
	number	14	13	15	12
Pore Water Drainage	mean	73			
	range	27			
	min.	59			
	max.	86			
	std. dev.	9			
	number	8			
All Samples	mean	44	23	16	17
	range	96	30	11	12
	min.	14	14	10	11
	max.	110	44	21	23
	std. dev.	26	6	3	3
	number	46	32	47	45

Table C'75

Tidal Statistics for Turbidity at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

TURBIDITY (FTU)

		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Flood	mean	27	20	13	15
	range	98	43	21	28
	min.	7	7	6	5
	max.	105	50	27	33
	std. dev.	24	13	6	9
	number	17	16	20	22
High Slack	mean	13	10	9	11
	range	4	0	7	7
	min.	11	10	6	7
	max.	15	10	13	14
	std. dev.	2	0	3	4
	number	5	2	5	3
Ebb	mean	17	11	10	10
	range	32	8	9	6
	min.	10	6	6	6
	max.	42	14	15	12
	std. dev.	9	3	2	2
	number	14	8	17	19
Low Slack	mean	30		10	9
	range	22		3	5
	min.	18		8	7
	max.	40		11	12
	std. dev.	11		1	2
	number	3		4	5
Pore Water Drainage	mean	37			
	range	49			
	min.	18			
	max.	67			
	std. dev.	21			
	number	4			
Preprecipitational Ebb	mean	12		12	14
	range	4		4	0
	min.	11		10	14
	max.	12		14	14
	std. dev.	0		2	0
	number	4		4	2
All Samples	mean	25	17	11	12
	range	113	44	21	28
	min.	7	6	6	5
	max.	120	50	27	33
	std. dev.	23	11	4	6
	number	46	33	53	52

Table C'76

Tidal Statistics for Dissolved Orthophosphate at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

DISSOLVED ORTHOPHOSPHATE (mg/l)

		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha*	beta	alpha	beta	alpha*	beta
Low Slack	mean	0.084	0.091			0.042	0.032	0.040	0.051
	range	0.062	0.105			0.014	0.012	0.019	0.018
	min.	0.049	0.025			0.039	0.025	0.030	0.044
	max.	0.111	0.130			0.053	0.037	0.049	0.062
	std. dev.	0.031	0.048			0.007	0.006	0.006	0.008
	number	4	4			4	4	6	4
Flood	mean	0.062	0.082	0.044	0.042	0.036	0.031	0.040	0.036
	range	0.022	0.094	0.032	0.020	0.009	0.011	0.024	0.011
	min.	0.049	0.049	0.031	0.033	0.033	0.026	0.030	0.029
	max.	0.071	0.143	0.063	0.053	0.042	0.037	0.054	0.040
	std. dev.	0.009	0.042	0.011	0.009	0.004	0.005	0.009	0.005
	number	4	4	10	4	4	4	10	4
High Slack	mean	0.054	0.071	0.056	0.042	0.041	0.030	0.033	0.052
	range	0.023	0.060	0.056	0.048	0.020	0.014	0.015	0.026
	min.	0.045	0.049	0.030	0.024	0.032	0.025	0.024	0.039
	max.	0.068	0.109	0.086	0.072	0.052	0.039	0.039	0.065
	std. dev.	0.010	0.028	0.021	0.022	0.008	0.006	0.005	0.012
	number	4	4	5	4	4	4	10	4
Ebb	mean	0.065	0.105	0.053	0.077	0.044	0.039	0.047	0.050
	range	0.025	0.053	0.052	0.030	0.016	0.017	0.030	0.016
	min.	0.056	0.072	0.032	0.061	0.033	0.031	0.034	0.040
	max.	0.081	0.125	0.084	0.091	0.049	0.048	0.064	0.056
	std. dev.	0.011	0.023	0.015	0.012	0.007	0.007	0.010	0.007
	number	4	4	13	4	4	4	12	4
Pore Water Drainage	mean	0.078	0.102						
	range	0.108	0.080						
	min.	0.038	0.061						
	max.	0.146	0.141						
	std. dev.	0.047	0.033						
	number	4	4						
All Samples	mean	0.069	0.090	0.050	0.054	0.041	0.033	0.041	0.047
	range	0.108	0.118	0.056	0.067	0.021	0.023	0.040	0.036
	min.	0.038	0.025	0.030	0.024	0.032	0.025	0.024	0.029
	max.	0.146	0.413	0.086	0.091	0.053	0.048	0.064	0.065
	std. dev.	0.026	0.034	0.014	0.022	0.007	0.007	0.009	0.010
	number	20	20	32	12	16	16	44	16

* These statistics from hourly data, noncomposite. Samples were not composited in order to study the hourly variations in concentrations rather than compositing the samples before analysis

Table C'77

Tidal Statistics for Dissolved Orthophosphate at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

DISSOLVED ORTHOPHOSPHATE (mg/l)

		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Flood	mean	0.048	0.057	0.044	0.040	0.027	0.037	0.032	0.036
	range	0.030	0.018	0.024	0.022	0.010	0.022	0.009	0.011
	min.	0.039	0.048	0.032	0.029	0.021	0.038	0.029	0.031
	max.	0.069	0.066	0.056	0.051	0.031	0.050	0.038	0.042
	std. dev.	0.012	0.008	0.011	0.010	0.004	0.009	0.004	0.005
	number	5	5	5	5	5	5	5	5
High Slack	mean	0.043	0.068	0.044	0.036	0.034	0.042	0.036	0.041
	range	0.008	0.027	0.015	0.027	0.020	0.021	0.003	0.005
	min.	0.038	0.055	0.036	0.023	0.022	0.032	0.034	0.038
	max.	0.046	0.082	0.051	0.050	0.042	0.053	0.037	0.043
	std. dev.	0.004	0.014	0.011	0.019	0.011	0.011	0.002	0.004
	number	3	3	2	2	3	3	2	2
Ebb	mean	0.042	0.056	0.033	0.035	0.029	0.036	0.033	0.039
	range	0.026	0.018	0.023	0.007	0.009	0.013	0.011	0.026
	min.	0.031	0.044	0.022	0.032	0.024	0.029	0.026	0.025
	max.	0.057	0.062	0.045	0.039	0.033	0.042	0.037	0.051
	std. dev.	0.011	0.008	0.012	0.004	0.004	0.005	0.005	0.011
	number	4	4	3	3	4	4	4	4
Low Slack	mean	0.034	0.044			0.023	0.028	0.029	0.032
	range	0.058	0.015			0.007	0.009	0.007	0.011
	min.	0.012	0.035			0.019	0.023	0.025	0.026
	max.	0.070	0.050			0.026	0.032	0.032	0.037
	std. dev.	0.025	0.007			0.005	0.006	0.005	0.008
	number	4	4			2	2	2	2
Pore Water Drainage	mean	0.041	0.043						
	range	0.038	0.048						
	min.	0.019	0.023						
	max.	0.057	0.071						
	std. dev.	0.018	0.021						
	number	4	4						
Preprecipitational Ebb	mean			0.043	0.043	0.029	0.039	0.033	0.037
	range			---	---	---	---	---	---
	min.			---	---	---	---	---	---
	max.			---	---	---	---	---	---
	std. dev.			---	---	---	---	---	---
	number			1	1	1	1	1	1
All Samples	mean	0.042	0.053	0.041	0.038	0.028	0.037	0.032	0.037
	range	0.058	0.059	0.034	0.028	0.023	0.030	0.013	0.026
	min.	0.012	0.023	0.022	0.023	0.019	0.023	0.025	0.025
	max.	0.070	0.082	0.056	0.051	0.042	0.053	0.038	0.051
	std. dev.	0.015	0.014	0.011	0,009	0.006	0.008	0.004	0.007
	number	20	20	11	11	15	15	14	14

Table C'78

Tidal Statistics for Dissolved Total Phosphorus at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

DISSOLVED TOTAL PHOSPHORUS (mg/l)

		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Low Slack	mean	0.126	0.116			0.061	0.062	0.071	0.123
	range	0.099	0.080			0.014	0.022	0.075	0.030
	min.	0.077	0.067			0.055	0.051	0.042	0.107
	max.	0.176	0.147			0.069	0.073	0.117	0.137
	std. dev.	0.044	0.037			0.006	0.009	0.032	0.012
	number	4	4			4	4	4	4
Flood	mean	0.086	0.101	0.072	0.082	0.058	0.048	0.078	0.118
	range	0.038	0.093	0.046	0.008	0.008	0.029	0.101	0.059
	min.	0.063	0.058	0.053	0.078	0.054	0.031	0.043	0.095
	max.	0.101	0.151	0.099	0.086	0.062	0.060	0.144	0.154
	std. dev.	0.017	0.039	0.020	0.003	0.004	0.012	0.046	0.025
	number	4	4	4	4	4	4	4	4
High Slack	mean	0.070	0.091	0.075	0.077	0.062	0.056	0.102	0.143
	range	0.038	0.078	0.018	0.014	0.022	0.019	0.111	0.056
	min.	0.054	0.053	0.066	0.072	0.049	0.047	0.063	0.122
	max.	0.092	0.131	0.084	0.086	0.071	0.066	0.174	0.178
	std. dev.	0.019	0.034	0.008	0.007	0.009	0.008	0.052	0.025
	number	4	4	4	4	4	4	4	4
Ebb	mean	0.082	0.119	0.073	0.102	0.062	0.063	0.098	0.137
	range	0.036	0.051	0.029	0.016	0.021	0.020	0.101	0.045
	min.	0.063	0.091	0.058	0.092	0.049	0.056	0.052	0.113
	max.	0.099	0.143	0.087	0.108	0.070	0.076	0.153	0.158
	std. dev.	0.017	0.023	0.012	0.007	0.009	0.009	0.043	0.020
	number	4	4	4	4	4	4	4	4
Pore Water Drainage	mean	0.105	0.132						
	range	0.141	0.093						
	min.	0.055	0.082						
	max.	0.196	0.175						
	std. dev.	0.064	0.038						
	number	4	4						
All Samples	mean	0.094	0.112	0.073	0.087	0.061	0.057	0.087	0.130
	range	0.142	0.122	0.046	0.036	0.022	0.045	0.132	0.083
	min.	0.054	0.053	0.053	0.072	0.049	0.031	0.042	0.095
	max.	0.196	0.175	0.099	0.108	0.071	0.076	0.174	0.178
	std. dev.	0.039	0.034	0.013	0.012	0.007	0.011	0.041	0.022
	number	20	20	12	12	16	16	16	16

Table C'79

Tidal Statistics for Dissolved Total Phosphorus at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

DISSOLVED TOTAL PHOSPHORUS (mg/l)

		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Flood	mean	0.098	0.109	0.128	0.121	0.099	0.107	0.086	0.094
	range	0.043	0.079	0.031	0.018	0.027	0.023	0.030	0.012
	min.	0.082	0.073	0.110	0.112	0.087	0.098	0.070	0.086
	max.	0.125	0.152	0.141	0.130	0.114	0.121	0.100	0.098
	std. dev.	0.017	0.030	0.014	0.008	0.010	0.008	0.013	0.005
	number	5	5	5	5	5	5	5	5
High Slack	mean	0.079	0.090	0.124	0.116	0.104	0.115	0.110	0.098
	range	0.012	0.012	0.004	0.018	0.005	0.012	0.045	0.001
	min.	0.073	0.083	0.122	0.107	0.101	0.109	0.087	0.097
	max.	0.085	0.095	0.126	0.125	0.106	0.121	0.132	0.098
	std. dev.	0.006	0.006	0.003	0.013	0.003	0.006	0.032	0.001
	number	3	3	2	2	3	3	2	2
Ebb	mean	0.101	0.095	0.118	0.120	0.102	0.106	0.097	0.103
	range	0.052	0.028	0.020	0.012	0.024	0.031	0.049	0.027
	min.	0.079	0.085	0.109	0.113	0.089	0.096	0.077	0.085
	max.	0.131	0.113	0.129	0.125	0.106	0.121	0.132	0.098
	std. dev	0.025	0.012	0.010	0.006	0.010	0.014	0.021	0.013
	number	4	4	3	3	4	4	4	4
Low Slack	mean	0.109	0.114			0.105	0.099	0.087	0.090
	range	0.041	0.048			0.014	0.003	0.028	0.014
	min.	0.087	0.097			0.098	0.097	0.073	0.083
	max.	0.128	0.145			0.112	0.100	0.101	0.097
	std. dev.	0.017	0.021			0.010	0.002	0.020	0.010
	number	4	4			2	2	2	2
Pore Water Drainage	mean	0.113	0.116						
	range	0.036	0.078						
	min.	0.089	0.078						
	max.	0.125	0.156						
	std. dev.	0.017	0.033						
	number	4	4						
Preprecipi-tational Ebb	mean			0.139	0.128	0.087	0.085	0.081	0.108
	range			---	---	---	---	---	---
	min.			---	---	---	---	---	---
	max.			---	---	---	---	---	---
	std. dev.			---	---	---	---	---	---
	number			1	1	1	1	1	1
All Samples	mean	0.101	0.106	0.126	0.120	0.101	0.106	0.092	0.097
	range	0.058	0.083	0.032	0.023	0.027	0.042	0.062	0.029
	min.	0.073	0.073	0.109	0.107	0.087	0.085	0.070	0.083
	max.	0.131	0.156	0.141	0.130	0.114	0.127	0.132	0.112
	std. dev.	0.019	0.024	0.012	0.008	0.009	0.011	0.018	0.009
	number	20	20	11	11	15	15	14	14

Table C'80

Tidal Statistics for Total Phosphorus at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

TOTAL PHOSPHORUS* (mg/l)

		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Low Slack	mean	0.291		0.146	0.154
	range	0.211		0.064	0.076
	min.	0.168		0.122	0.127
	max.	0.379		0.186	0.203
	std. dev.	0.088		0.028	0.036
	number	4		4	4
Flood	mean	0.127	0.216	0.149	0.172
	range	0.002	0.137	0.036	0.067
	min.	0.171	0.137	0.137	0.151
	max.	0.173	0.312	0.173	0.218
	std. dev.	0.001	0.065	0.016	0.031
	number	3	4	4	4
High Slack	mean	0.212	0.206	0.159	0.156
	range	0.177	0.109	0.038	0.077
	min.	0.119	0.152	0.140	0.129
	max.	0.296	0.261	0.178	0.206
	std. dev.	0.073	0.052	0.021	0.035
	number	4	4	4	4
Ebb	mean	0.183	0.214	0.135	0.165
	range	0.110	0.144	0.041	0.073
	min.	0.124	0.137	0.115	0.125
	max.	0.234	0.281	0.156	0.198
	std. dev.	0.054	0.059	0.019	0.031
	number	4	4	4	4
Pore Water Drainage	mean	0.356			
	range	0.182			
	min.	0.264			
	max.	0.446			
	std. dev.	0.091			
	number	4			
All Samples	mean	0.251	0.214	0.147	0.162
	range	0.327	0.175	0.071	0.093
	min.	0.119	0.137	0.115	0.125
	max.	0.446	0.312	0.186	0.218
	std. dev.	0.097	0.052	0.021	0.031
	number	18	13	16	16

* Analysis of unfiltered samples after acid digestion

Table C'81

Tidal Statistics for Total Phosphorus at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

TOTAL PHOSPHORUS* (mg/l)

		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Flood	mean	0.212	0.223	0.259	0.274	0.167	0.194	0.166	0.178
	range	0.154	0.142	0.058	0.037	0.080	0.100	0.063	0.075
	min.	0.157	0.179	0.225	0.249	0.123	0.156	0.134	0.123
	max.	0.311	0.321	0.283	0.286	0.203	0.256	0.197	0.198
	std. dev.	0.060	0.057	0.022	0.015	0.035	0.039	0.029	0.031
	number	5	5	5	5	5	5	5	5
High Slack	mean	0.170	0.191	0.242	0.269	0.199	0.223	0.197	0.167
	range	0.021	0.029	0.014	0.049	0.048	0.069	0.067	0.027
	min.	0.161	0.179	0.235	0.245	0.179	0.189	0.163	0.153
	max.	0.182	0.208	0.249	0.294	0.227	0.258	0.230	0.180
	std. dev.	0.011	0.015	0.010	0.035	0.025	0.035	0.047	0.019
	number	3	3	2	2	3	3	2	2
Ebb	mean	0.207	0.226	0.237	0.236	0.178	0.176	0.179	0.190
	range	0.053	0.079	0.035	0.048	0.057	0.095	0.086	0.044
	min.	0.179	0.185	0.219	0.211	0.145	0.132	0.145	0.172
	max.	0.232	0.264	0.254	0.259	0.202	0.229	0.231	0.216
	std. dev.	0.024	0.036	0.018	0.024	0.026	0.049	0.037	0.021
	number	4	4	3	3	4	4	4	4
Low Slack	mean	0.247	0.236			0.184	0.213	0.166	0.167
	range	0.086	0.139			0.041	0.022	0.056	0.003
	min.	0.197	0.188			0.163	0.202	0.138	0.165
	max.	0.283	0.327			0.204	0.224	0.194	0.168
	std. dev.	0.036	0.063			0.029	0.016	0.040	0.002
	number	4	4			2	2	2	2
Pore Water Drainage	mean	0.224	0.258						
	range	0.149	0.134						
	min.	0.159	0.189						
	max.	0.308	0.323						
	std. dev.	0.062	0.055						
	number	4	4						
Preprecipitational Ebb	mean			0.262	0.278	0.110	0.105	0.149	0.224
	range			---	---	---	---	---	---
	min.			---	---	---	---	---	---
	max.			---	---	---	---	---	---
	std. dev.			---	---	---	---	---	---
	number			1	1	1	1	1	1
All Samples	mean	0.214	0.228	0.250	0.263	0.175	0.192	0.173	0.182
	range	0.154	0.148	0.064	0.083	0.117	0.153	0.097	0.101
	min.	0.157	0.179	0.219	0.211	0.110	0.105	0.134	0.123
	max.	0.311	0.327	0.283	0.294	0.227	0.258	0.231	0.224
	std. dev.	0.047	0.050	0.020	0.025	0.033	0.045	0.032	0.026
	number	20	20	11	11	15	15	14	14

* Analysis of unfiltered samples after acid digestion

Table C'82

Tidal Statistics for Dissolved Ammonium at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

DISSOLVED AMMONIUM* (mg/l)

		Artificial Marsh		Natural Marsh	
Tidal Stage		**Pipe**	**Breach**	**Large channel**	**Small channel**
Low Slack	**mean**	0.46		0.43	0.46
	range	0.17		0.23	0.05
	min.	0.39		0.29	0.43
	max.	0.56		0.52	0.49
	std. dev.	0.08		0.10	0.02
	number	4		4	4
Flood	**mean**	0.36	0.51	0.55	0.49
	range	0.30	0.27	0.22	0.24
	min.	0.22	0.40	0.46	0.32
	max.	0.53	0.67	0.67	0.56
	std. dev.	0.13	0.12	0.09	0.11
	number	4	4	4	4
High Slack	**mean**	0.50	0.49	0.47	0.40
	range	0.56	0.32	0.33	0.20
	min.	0.34	0.29	0.33	0.31
	max.	0.89	0.61	0.66	0.51
	std. dev.	0.27	0.14	0.14	0.09
	number	4	4	4	4
Ebb	**mean**	0.41	0.54	0.47	0.49
	range	0.17	0.04	0.25	0.18
	min.	0.33	0.52	0.29	0.39
	max.	0.50	0.56	0.54	0.57
	std. dev.	0.09	0.02	0.12	0.08
	number	4	4	4	4
Pore Water Drainage	**mean**	0.56			
	range	0.38			
	min.	0.42			
	max.	0.79			
	std. dev.	0.16			
	number	4			
All Samples	**mean**	0.46	0.51	0.48	0.46
	range	0.67	0.38	0.38	0.26
	min.	0.22	0.29	0.29	0.31
	max.	0.89	0.67	0.67	0.57
	std. dev.	0.16	0.10	0.11	0.08
	number	20	12	16	16

* Composite samples stored at 4°C with H_2SO_4 for seven days

Table C'83

Tidal Statistics for Dissolved Ammonium at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

DISSOLVED AMMONIUM* (mg/l)

		Artificial Marsh							
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Low Slack	mean	0.57	0.48			0.49	0.54	0.68	0.71
	range	0.27	0.37			0.41	0.47	0.37	0.33
	min.	0.47	0.32			0.33	0.37	0.47	0.53
	max.	0.74	0.69			0.74	0.84	0.84	0.86
	std. dev.	0.12	0.16			0.22	0.26	0.18	0.17
	number	4	4			3	3	4	4
Flood	mean	0.60	0.63	0.57	0.52	0.56	0.55	0.77	0.64
	range	0.46	0.43	0.15	0.24	0.53	0.35	0.18	0.48
	min.	0.45	0.41	0.51	0.40	0.26	0.31	0.68	0.40
	max.	0.91	0.84	0.66	0.64	0.79	0.66	0.86	0.88
	std. dev.	0.21	0.18	0.08	0.10	0.23	0.16	0.08	0.20
	number	4	4	4	4	4	4	4	4
High Slack	mean	0.46	0.43	0.57	0.61	0.63	0.60	0.62	0.51
	range	0.35	0.26	0.40	0.60	0.33	0.44	0.72	0.58
	min.	0.34	0.32	0.33	0.39	0.51	0.41	0.26	0.32
	max.	0.69	0.58	0.73	0.99	0.84	0.85	0.98	0.90
	std. dev.	0.16	0.12	0.20	0.26	0.18	0.18	0.30	0.26
	number	4	4	4	4	3	4	4	4
Ebb	mean	0.62	0.72	0.56	0.61	0.58	0.54	0.71	0.70
	range	0.15	0.11	0.34	0.32	0.32	0.22	0.60	0.50
	min.	0.53	0.67	0.38	0.49	0.45	0.45	0.44	0.47
	max.	0.68	0.78	0.72	0.81	0.77	0.67	1.04	0.97
	std. dev.	0.06	0.05	0.15	0.14	0.14	0.10	0.25	0.21
	number	4	4	4	4	4	4	4	4
Pore Water Drainage	mean	0.72	0.66						
	range	0.79	0.72						
	min.	0.37	0.31						
	max.	1.16	1.03						
	std. dev.	0.34	0.32						
	number	4	4						
All Samples	mean	0.59	0.59	0.57	0.58	0.57	0.56	0.69	0.64
	range	0.82	0.72	0.40	0.60	0.58	0.54	0.78	0.65
	min.	0.34	0.31	0.33	0.39	0.26	0.31	0.26	0.32
	max.	1.16	1.03	0.73	0.99	0.84	0.85	1.04	0.97
	std. dev.	0.20	0.20	0.13	0.17	0.18	0.16	0.20	0.21
	number	20	20	12	12	14	15	16	16

* Composite samples stored frozen with perchloric acid for six weeks

Table C'84

Tidal Statistics for Dissolved Ammonium at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

DISSOLVED AMMONIUM (mg/l)

		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Flood	mean	0.49	0.42	0.46	0.45	0.39	0.37	0.54	0.44
	range	0.33	0.09	0.15	0.14	0.15	0.10	0.47	0.27
	min.	0.36	0.38	0.41	0.40	0.31	0.34	0.35	0.32
	max.	0.69	0.47	0.56	0.54	0.46	0.44	0.82	0.59
	std. dev.	0.12	0.04	0.06	0.06	0.06	0.04	0.19	0.10
	number	5	5	5	5	5	5	5	5
High Slack	mean	0.38	0.42	0.44	0.48	0.62	0.67	0.50	0.42
	range	0.06	0.09	0.25	0.23	0.69	0.90	0.17	0.08
	min.	0.36	0.37	0.32	0.37	0.28	0.34	0.42	0.38
	max.	0.42	0.46	0.57	0.60	0.97	1.24	0.59	0.46
	std. dev.	0.04	0.05	0.18	0.16	0.34	0.49	0.12	0.06
	number	3	3	2	2	3	3	2	2
Ebb	mean	0.58	0.51	0.42	0.44	0.57	0.57	0.36	0.34
	range	0.51	0.49	0.03	0.15	0.39	0.51	0.14	0.17
	min.	0.36	0.36	0.40	0.38	0.38	0.33	0.29	0.27
	max.	0.87	0.85	0.43	0.53	0.77	0.84	0.43	0.44
	std. dev.	0.24	0.23	0.02	0.08	0.16	0.24	0.06	0.08
	number	4	4	3	3	4	4	4	4
Low Slack	mean	0.50	0.52			0.30	0.34	0.41	0.40
	range	0.09	0.10			0.13	0.01	0.18	0.09
	min.	0.45	0.47			0.24	0.33	0.32	0.35
	max.	0.54	0.57			0.37	0.34	0.50	0.44
	std. dev.	0.04	0.04			0.09	0.01	0.13	0.06
	number	4	4			2	2	2	2
Pore Water Drainage	mean	0.44	0.44						
	range	0.10	0.17						
	min.	0.40	0.37						
	max.	0.50	0.54						
	std. dev.	0.04	0.07						
	number	4	4						
Preprecipitational Ebb	mean			0.50	0.41	0.55	0.40	0.36	0.35
	range			---	---	---	---	---	---
	min.			---	---	---	---	---	---
	max.			---	---	---	---	---	---
	std. dev.			---	---	---	---	---	---
	number			1	1	1	1	1	1
All Samples	mean	0.48	0.46	0.45	0.45	0.48	0.48	0.45	0.40
	range	0.51	0.49	0.25	0.23	0.73	0.91	0.53	0.32
	min.	0.36	0.36	0.32	0.37	0.24	0.33	0.29	0.27
	max.	0.87	0.85	0.57	0.60	0.97	1.24	0.82	0.59
	std. dev.	0.13	0.11	0.07	0.07	0.19	0.26	0.15	0.08
	number	20	20	11	11	15	15	14	14

Table C'85

Tidal Statistics for Dissolved Nitrate Plus Nitrite at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

DISSOLVED NITRATE PLUS NITRITE (mg/1)

		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha*	beta	alpha	beta	alpha*	beta
Low Slack	mean	0.399	0.370			0.365	0.390	0.561	0.394
	range	0.382	0.310			0.173	0.275	1.553	0.422
	min.	0.168	0.171			0.263	0.271	0.226	0.266
	max.	0.550	0.481			0.436	0.546	1.779	0.688
	std. dev.	0.163	0.138			0.076	0.119	0.607	0.198
	number	4	4			4	4	6	4
Flood	mean	0.648	0.690	0.680	0.663	0.417	0.410	0.607	0.527
	range	0.280	0.186	0.345	0.268	0.082	0.306	0.455	0.136
	min.	0.477	0.556	0.448	0.497	0.385	0.259	0.294	0.433
	max.	0.757	0.742	0.793	0.765	0.467	0.565	0.749	0.569
	std. dev.	0.120	0.090	0.118	0.115	0.037	0.129	0.136	0.063
	number	4	4	10	4	4	4	10	4
High Slack	mean	0.671	0.686	0.793	0.706	0.623	0.540	0.708	0.649
	range	0.085	0.235	0.283	0.099	0.360	0.175	0.577	0.095
	min.	0.649	0.552	0.631	0.665	0.493	0.449	0.371	0.621
	max.	0.734	0.787	0.914	0.764	0.853	0.624	0.948	0.716
	std. dev.	0.042	0.100	0.105	0.048	0.160	0.085	0.204	0.045
	number	4	4	5	4	4	4	10	4
Ebb	mean	0.661	0.588	0.666	0.697	0.541	0.415	0.693	0.486
	range	0.555	0.190	0.673	0.346	0.215	0.284	1.047	0.252
	min.	0.495	0.514	0.373	0.561	0.407	0.268	0.276	0.372
	max.	1.050	0.704	1.046	0.907	0.622	0.552	1.323	0.624
	std. dev.	0.261	0.082	0.201	0.164	0.100	0.119	0.340	0.108
	number	4	4	13	4	4	4	12	4
Pore Water Drainage	mean	0.315	0.337						
	range	0.318	0.222						
	min.	0.220	0.274						
	max.	0.538	0.496						
	std. dev.	0.150	0.107						
	number	4	4						
All Samples	mean	0.539	0.534	0.711	0.688	0.487	0.439	0.654	0.514
	range	0.882	0.616	0.869	0.410	0.590	0.365	1.553	0.450
	min.	0.168	0.171	0.373	0.497	0.263	0.259	0.226	0.266
	max.	1.050	0.787	1.242	0.907	0.853	0.624	1.779	0.716
	std. dev.	0.212	0.182	0.178	0.109	0.140	0.119	0.298	0.143
	number	20	20	32	12	16	16	44	16

* These statistics from hourly data, noncomposites. Samples were not composited in order to study the hourly variations in concentrations rather than compositing the samples before analysis

Table C'86

Tidal Statistics for Dissolved Nitrate Plus Nitrite at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

DISSOLVED NITRATE PLUS NITRITE (mg/l)

		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Flood	mean	2.09	2.15	1.74	1.78	1.55	1.61	1.46	1.58
	range	1.30	0.04	0.74	1.06	1.09	1.06	0.82	0.45
	min.	1.57	1.64	1.44	1.26	0.98	0.98	1.07	1.37
	max.	2.87	2.68	2.18	2.32	2.07	2.04	1.89	1.82
	std. dev.	0.50	0.40	0.27	0.46	0.42	0.47	0.37	0.18
	number	5	5	5	5	5	5	5	5
High Slack	mean	1.72	2.02	2.06	1.73	1.74	1.67	1.84	2.00
	range	1.33	0.23	0.72	0.18	1.44	0.50	0.33	0.39
	min.	1.13	1.94	1.70	1.64	1.11	1.48	1.68	1.80
	max.	2.46	2.17	2.42	1.82	2.55	1.98	2.01	2.19
	std. dev.	0.68	0.13	0.51	0.13	0.74	0.27	0.23	0.28
	number	3	3	2	2	3	3	2	2
Ebb	mean	2.17	2.27	1.81	2.05	1.86	1.56	1.47	1.58
	range	1.85	1.35	0.51	0.56	1.37	0.41	0.11	0.80
	min.	1.23	1.70	1.56	1.69	1.34	1.34	1.42	1.12
	max.	3.08	3.05	2.07	2.25	2.71	1.75	1.53	1.92
	std. dev.	0.78	0.58	0.26	0.32	0.62	0.20	0.06	0.34
	number	4	4	3	3	4	4	4	4
Low Slack	mean	1.69	2.14			1.86	1.82	1.43	1.54
	range	1.21	1.09			1.06	0.39	1.34	0.15
	min.	1.08	1.60			1.33	1.63	0.76	1.47
	max.	2.29	2.69			2.39	2.02	2.10	1.62
	std. dev.	0.68	0.50			0.75	0.28	0.95	0.11
	number	4	4			2	2	2	2
Pore Water Drainage	mean	2.10	2.30						
	range	1.30	0.70						
	min.	1.35	1.91						
	max.	2.65	2.61						
	std. dev.	0.58	0.29						
	number	4	4						
Preprecipitational Ebb	mean			1.45	1.61	1.09	1.48	1.22	1.09
	range			----	----	----	----	----	----
	min.			----	----	----	----	----	----
	max.			----	----	----	----	----	----
	std. dev.			----	----	----	----	----	----
	number			1	1	1	1	1	1
All Samples	mean	1.97	2.19	1.79	1.83	1.68	1.63	1.50	1.60
	range	2.00	1.45	0.98	1.06	1.73	1.06	1.34	1.10
	min.	1.08	1.60	1.44	1.26	0.98	0.98	0.76	1.09
	max.	3.08	3.05	2.42	2.32	2.71	2.04	2.10	2.19
	std. dev.	0.60	0.39	0.31	0.36	0.54	0.31	0.38	0.30
	number	20	20	11	11	15	15	14	14

Table C'87

Tidal Statistics for Dissolved Total Nitrogen at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

DISSOLVED TOTAL NITROGEN (mg/l)									
		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Low Slack	mean	3.66	3.39			2.92	1.22	1.58	0.62
	range	5.85	5.52			0.73	1.70	1.19	0.58
	min.	1.29	0.82			2.66	0.59	0.97	0.41
	max.	7.13	6.34			3.39	2.29	2.16	1.00
	std. dev.	2.81	2.50			0.32	0.74	0.49	0.27
	number	4	4			4	4	4	4
Flood	mean	2.86	2.96	3.00	3.86	3.04	1.13	2.07	1.18
	range	3.22	2.84	3.75	1.03	3.31	1.60	1.42	0.66
	min.	1.20	1.31	1.28	3.42	1.21	0.35	1.27	0.79
	max.	4.41	4.16	4.03	4.45	4.52	1.95	2.68	1.45
	std. dev.	1.32	1.37	1.20	0.50	1.52	0.66	0.69	0.31
	number	4	4	4	4	4	4	4	4
High Slack	mean	2.31	3.19	2.89	4.10	4.18	1.284	1.917	0.965
	range	2.60	3.58	1.44	0.91	9.36	0.417	0.969	0.669
	min.	1.53	1.28	2.02	3.59	0.89	0.076	1.265	0.786
	max.	4.12	4.86	3.46	4.50	10.25	1.493	2.234	1.455
	std. dev.	1.22	1.48	0.69	0.39	4.24	0.237	0.445	0.328
	number	4	4	4	4	4	4	4	4
Ebb	mean	4.47	5.06	3.88	4.18	2.58	1.11	1.49	0.79
	range	0.66	1.48	2.47	1.51	4.28	0.83	0.71	0.65
	min.	4.25	4.04	2.35	3.31	0.65	0.87	0.82	0.43
	max.	4.91	5.52	4.82	4.82	4.92	1.70	2.53	1.08
	std. dev.	0.30	0.69	1.07	0.64	1.87	0.40	0.76	0.30
	number	4	4	4	4	4	4	4	4
Pore Water Drainage	mean	1.91	3.16						
	range	0.37	0.92						
	min.	1.69	2.79						
	max.	2.06	3.71						
	std. dev.	0.17	0.39						
	number	4							
All Samples	mean	3.04	3.55	3.26	4.05	3.18	1.19	1.76	0.89
	range	5.93	5.52	3.54	1.51	9.60	1.95	1.86	1.04
	min.	1.20	0.82	1.28	3.31	0.65	0.35	0.82	0.41
	max.	7.13	5.34	4.82	4.82	10.25	2.29	2.68	1.46
	std. dev.	1.64	1.53	1.03	0.49	2.27	0.50	0.60	0.34
	number	20	20	12	12	16	16	16	16

Table C'88

Tidal Statistics for Total Dissolved Nitrogen at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

DISSOLVED TOTAL NITROGEN (mg/l)

		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Flood	mean	2.75	2.82	2.40	2.39	2.00	2.20	2.37	2.21
	range	0.38	0.62	1.20	0.79	1.84	1.42	1.07	0.72
	min.	2.56	2.50	1.61	1.84	1.13	1.34	1.79	1.77
	max.	2.94	3.12	2.81	2.63	2.97	2.76	2.86	2.49
	std. dev.	0.14	0.28	0.47	0.35	0.67	0.58	0.39	0.27
	number	5	5	5	5	5	5	5	5
High Slack	mean	2.14	2.43	2.12	1.96	2.70	2.65	2.32	2.32
	range	1.45	0.98	0.81	0.19	1.35	1.31	0.23	0.05
	min.	1.24	2.06	1.72	1.87	2.07	2.08	2.21	2.29
	max.	2.69	3.03	2.53	2.06	3.42	3.39	2.44	2.34
	std. dev.	0.79	0.52	0.57	0.13	0.68	0.67	0.16	0.04
	number	3	3	2	2	3	3	2	2
Ebb	mean	2.60	2.64	2.47	2.53	3.07	3.33	2.21	2.32
	range	1.11	1.00	0.06	0.11	1.76	1.00	0.80	0.79
	min.	2.04	2.21	2.43	2.47	2.07	2.96	1.68	1.79
	max.	3.15	3.21	2.49	2.58	3.83	3.96	2.48	2.58
	std. dev.	0.46	0.43	0.03	0.06	0.74	0.47	0.36	0.36
	number	4	4	3	3	4	4	4	4
Low Slack	mean	2.76	2.98			2.43	2.74	2.71	2.50
	range	1.91	0.94			0.98	1.01	1.30	0.23
	min.	1.67	2.49			1.94	2.24	2.06	2.38
	max.	3.58	3.43			2.92	3.25	3.36	2.61
	std. dev.	0.83	0.45			0.69	0.71	0.92	0.16
	number	4	4			2	2	2	2
Pore Water Drainage	mean	2.73	3.28						
	range	2.61	1.42						
	min.	1.53	2.66						
	max.	4.14	4.08						
	std. dev.	1.08	0.66						
	number	4	4						
Preprecipitational Ebb	mean			2.17	1.99	3.26	3.30	2.72	3.61
	range			---	---	---	---	---	---
	min.			---	---	---	---	---	---
	max.			---	---	---	---	---	---
	std. dev.			---	---	---	---	---	---
	number			1	1	1	1	1	1
All Samples	mean	2.63	2.85	2.35	2.32	2.57	2.74	2.39	2.40
	range	2.90	2.03	1.20	0.79	2.70	2.62	1.68	1.84
	min.	1.24	2.05	1.61	1.84	1.13	1.34	1.68	1.77
	max.	4.14	4.08	2.81	2.63	3.83	3.96	3.36	3.61
	std. dev.	0.66	0.51	0.37	0.32	0.76	0.69	0.42	0.43
	number	20	20	11	11	15	15	14	14

Table C'89

Tidal Statistics for Total Kjeldahl Nitrogen at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

TOTAL KJELDAHL NITROGEN* (mg/l)

		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Low Slack	mean	6.71		4.93	3.96
	range	4.89		2.50	3.68
	min.	4.35		4.13	1.88
	max.	9.24		6.63	5.56
	std. dev.	2.00		1.15	1.74
	number	4		4	4
Flood	mean	7.19	4.24	4.41	3.05
	range	0.95	3.79	1.72	1.76
	min.	6.71	2.93	3.30	2.48
	max.	7.66	6.72	5.02	4.24
	std. dev.	0.67	1.70	0.81	0.80
	number	2	4	4	4
High Slack	mean	5.42	4.03	3.94	3.14
	range	5.02	2.67	2.94	3.20
	min.	3.48	3.14	2.02	0.12
	max.	8.50	5.81	4.96	5.32
	std. dev.	2.16	1.21	1.31	1.4[illegible]
	number	4	4	4	4
Ebb	mean	5.91	5.27	5.42	4.90
	range	6.37	4.01	1.85	5.05
	min.	3.04	3.44	4.51	3.02
	max.	9.41	7.45	6.36	8.07
	std. dev.	2.82	1.78	0.76	2.35
	number	4	4	4	4
Pore Water Drainage	mean	4.61			
	range	4.25			
	min.	2.56			
	max.	6.81			
	std. dev.	2.22			
	number	4			
All Samples	mean	5.83	4.45	4.70	3.76
	range	6.85	4.52	4.61	6.19
	min.	2.56	2.93	2.02	1.88
	max.	9.41	7.45	6.63	8.07
	std. dev.	2.15	1.49	1.08	1.69
	number	18	13	16	16

* Analysis of unfiltered samples after acid digestion

Table C'90

Tidal Statistics for Total Kjeldahl Nitrogen* at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

TOTAL KJELDAHL NITROGEN* (mg/1)

		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Flood	mean	3.83	3.41	3.13	2.87	2.86	3.22	2.55	2.88
	range	2.14	1.27	2.34	1.92	5.04	4.46	2.23	1.76
	min.	3.02	2.98	1.72	1.89	1.20	1.51	1.52	2.08
	max.	5.16	4.25	4.06	3.81	6.24	5.97	3.75	3.84
	std. dev.	0.82	0.51	0.95	0.78	1.96	1.72	0.79	0.83
	number	5	5	5	5	5	5	5	5
High Slack	mean	2.45	3.61	2.28	2.65	3.74	3.43	3.30	2.91
	range	1.72	2.15	0.69	0.18	2.08	3.21	1.2.	1.06
	min.	1.45	2.30	1.94	2.56	2.58	2.15	2.70	2.38
	max.	3.17	4.45	2.63	2.74	4.66	5.36	3.91	3.44
	std. dev.	0.89	1.15	0.49	0.13	1.06	1.70	0.86	0.75
	number	3	3	2	2	3	3	2	2
Ebb	mean	3.15	3.98	2.93	2.89	3.48	4.09	2.88	3.24
	range	1.79	3.55	0.44	0.36	1.82	1.81	2.00	1.94
	min.	2.08	2.87	2.74	2.76	2.23	3.38	1.58	2.68
	max.	3.87	6.42	3.18	3.12	4.05	5.19	3.58	4.62
	std. dev.	0.76	1.64	0.23	0.20	0.86	0.80	0.92	0.92
	number	4	4	3	3	4	4	4	4
Low Slack	mean	3.90	3.86			2.98	3.68	2.44	2.98
	range	4.02	2.28			0.73	2.47	1.57	0.56
	min.	2.26	2.58			2.61	2.45	1.66	2.70
	max.	6.28	4.86			3.34	4.92	3.23	3.26
	std. dev.	1.72	1.05			0.52	1.75	1.11	0.40
	number	4	4			2	2	2	2
Pore Water Drainage	mean	3.81	4.57						
	range	2.73	2.84						
	min.	2.36	3.32						
	max.	5.09	6.16						
	std. dev.	1.19	1.33						
	number	4	4						
Preprecipitational Ebb	mean			3.42	1.98	4.53	6.15	5.20	4.72
	range			---	---	---	---	---	---
	min.			---	---	---	---	---	---
	max.			---	---	---	---	---	---
	std. dev.			---	---	---	---	---	---
	number			1	1	1	1	1	1
All Samples	mean	3.50	3.88	2.95	2.76	3.33	3.75	2.93	3.13
	range	4.83	4.12	2.34	1.92	5.04	4.64	3.68	2.64
	min.	1.45	2.30	1.72	1.89	1.20	1.51	1.52	2.08
	max.	6.28	6.42	4.06	3.81	6.24	6.15	5.20	4.72
	std. dev.	1.13	1.12	0.72	0.57	1.30	1.48	1.02	0.84
	number	20	20	11	11	15	15	14	14

* Analysis of unfiltered samples after acid digestion

Table C'91

Tidal Statistics for the Fo/Fa Ratio at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

Fo/Fa RATIO					
		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Low Slack	mean	1.66		1.83	1.82
	range	0.29		0.68	0.51
	min.	1.52		1.67	1.68
	max.	1.81		2.35	2.19
	std. dev.	0.11		0.24	0.18
	number	6		7	7
Flood	mean	1.70	1.72	1.72	1.77
	range	0.18	0.20	0.32	0.34
	min.	1.61	1.62	1.56	1.64
	max.	1.79	1.82	1.88	1.98
	std. dev.	0.06	0.08	0.08	0.10
	number	10	9	9	10
High Slack	mean	1.68	1.72	1.71	1.74
	range	0.38	0.24	0.26	0.35
	min.	1.52	1.62	1.62	1.65
	max.	1.90	1.86	1.88	2.00
	std. dev.	0.14	0.09	0.08	0.11
	number	5	5	10	9
Ebb	mean	1.71	1.77	1.76	1.71
	range	0.29	0.24	0.42	0.36
	min.	1.55	1.64	1.62	1.54
	max.	1.84	1.88	2.04	1.90
	std. dev.	0.09	0.08	0.13	0.10
	number	13	13	14	14
Pore Water Drainage	mean	1.60			
	range	0.40			
	min.	1.42			
	max.	1.82			
	std. dev.	0.15			
	number	8			
All Samples	mean	1.68	1.75	1.75	1.75
	range	0.48	0.26	0.79	0.65
	min.	1.42	1.62	1.56	1.54
	max.	1.90	1.88	2.35	2.19
	std. dev.	0.11	0.08	0.13	0.12
	number	45	31	45	46

Table C'92

Tidal Statistics for the Fo/Fa Ratio at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

Fo/Fa RATIO

Tidal Stage		Artificial Marsh		Natural Marsh	
		Pipe	Breach	Large channel	Small channel
Flood	mean	1.42	1.45	1.50	1.49
	range	0.29	0.16	0.19	0.18
	min.	1.29	1.37	1.43	1.40
	max.	1.58	1.53	1.62	1.58
	std. dev.	0.10	0.05	0.04	0.05
	number	17	15	20	20
High Slack	mean	1.50	1.54	1.48	1.52
	range	0.23	0.04	0.02	0.14
	min.	1.41	1.52	1.47	1.46
	max.	1.64	1.56	1.49	1.60
	std. dev.	0.10	0.03	0.01	0.07
	number	4	2	4	3
Ebb	mean	1.42	1.47	1.53	1.55
	range	0.19	0.21	0.23	0.22
	min.	1.29	1.36	1.38	1.47
	max.	1.48	1.57	1.61	1.69
	std. dev.	0.07	0.06	0.05	0.06
	number	12	8	16	17
Low Slack	mean	1.37		1.58	1.58
	range	0.16		0.11	0.10
	min.	1.28		1.54	1.52
	max.	1.44		1.65	1.62
	std. dev.	0.07		0.05	0.04
	number	4		4	5
Pore Water Drainage	mean	1.36			
	range	0.12			
	min.	1.30			
	max.	1.42			
	std. dev.	0.05			
	number	5			
Preprecipitational Ebb	mean		1.52	1.50	1.50
	range		0.03	0.07	0.06
	min.		1.50	1.46	1.47
	max.		1.53	1.53	1.53
	std. dev.		0.02	0.03	0.04
	number		2	4	2
All Samples	mean	1.42	1.46	1.52	1.52
	range	0.36	0.25	0.27	0.29
	min.	1.28	1.32	1.38	1.40
	max.	1.64	1.57	1.65	1.69
	std. dev.	0.08	0.06	0.05	0.06
	number	44	29	51	48

Table C'93

Tidal Statistics for Chlorophyll at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

CHLOROPHYLL (ug/l)

		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Low Slack	mean	12.25		17.90	18.34
	range	13.75		10.60	20.50
	min.	5.35		12.60	11.90
	max.	19.10		23.20	32.40
	std. dev.	5.45		4.59	6.78
	number	6		6	7
Flood	mean	10.68	11.31	15.68	13.94
	range	13.21	8.09	11.02	11.00
	min.	4.39	7.41	8.78	9.30
	max.	17.60	15.50	19.80	20.30
	std. dev.	3.90	2.95	4.03	3.44
	number	10	9	9	10
High Slack	mean	9.38	10.98	11.80	12.04
	range	6.14	8.38	11.37	8.55
	min.	6.86	8.92	4.93	7.25
	max.	13.00	17.30	16.30	15.80
	std. dev.	2.25	3.55	2.96	2.82
	number	5	5	10	9
Ebb	mean	9.64	10.02	12.24	12.15
	range	9.29	6.20	12.32	22.75
	min.	6.31	8.10	7.68	6.45
	max.	15.60	14.30	20.00	29.20
	std. dev.	2.64	1.74	3.53	5.62
	number	13	13	14	14
Pore Water Drainage	mean	7.60			
	range	6.46			
	min.	4.24			
	max.	10.70			
	std. dev.	2.22			
	number	8			
All Samples	mean	9.87	10.78	14.08	13.68
	range	14.86	9.89	19.27	25.95
	min.	4.24	7.41	4.93	6.45
	max.	19.10	17.30	24.20	32.40
	std. dev.	3.41	2.48	4.58	5.17
	number	45	31	44	46

Table C'94

Tidal Statistics for Chlorophyll at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

CHLOROPHYLL (μg/1)

		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Flood	mean	1.20	1.00	0.88	1.04
	range	3.65	1.16	1.12	1.41
	min.	0.66	0.62	0.62	0.62
	max.	4.31	1.78	1.74	2.03
	std. dev.	0.99	0.41	0.27	0.44
	number	16	15	20	20
High Slack	mean	0.74	0.68	0.72	0.73
	range	0.09	0.19	0.14	0.10
	min.	0.71	0.59	0.66	0.67
	max.	0.80	0.78	0.80	0.77
	std. dev.	0.04	0.13	0.06	0.05
	number	4	2	4	3
Ebb	mean	0.68	0.63	0.69	0.74
	range	0.70	0.49	0.38	0.40
	min.	0.49	0.48	0.47	0.59
	max.	1.19	0.97	0.85	0.99
	std. dev.	0.20	0.17	0.08	0.11
	number	12	8	16	17
Low Slack	mean	1.39		0.72	0.72
	range	2.57		0.15	0.17
	min.	0.59		0.63	0.63
	max.	3.16		0.78	0.80
	std. dev.	1.20		0.07	0.08
	number	4		4	5
Pore Water Drainage	mean	1.50			
	range	1.96			
	min.	0.59			
	max.	2.55			
	std. dev.	0.79			
	number	5			
Preprecipitational Ebb	mean		0.76	0.68	0.70
	range		0.02	0.14	0.00
	min.		0.75	0.60	0.70
	max.		0.77	0.74	0.70
	std. dev.		0.01	0.06	0.00
	number		2	4	2
All Samples	mean	1.21	0.92	0.77	0.86
	range	6.06	2.54	1.27	1.44
	min.	0.49	0.48	0.47	0.59
	max.	6.55	3.02	1.74	2.03
	std. dev.	1.15	0.53	0.20	0.33
	number	44	29	51	48

Table C'95

Tidal Statistics for Phaeophytin at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

		PHAEOPHYTIN (μg/l)			
		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Low Slack	mean	7.79		6.00	5.32
	range	15.78		2.75	7.00
	min.	1.92		4.39	1.37
	max.	17.70		7.14	8.37
	std. dev.	6.51		1.08	2.61
	number	6		6	6
Flood	mean	3.79	4.24	6.16	4.36
	range	3.84	4.11	6.45	7.69
	min.	1.92	2.20	2.47	0.41
	max.	5.76	6.31	8.92	8.10
	std. dev.	1.33	1.43	1.96	2.44
	number	10	9	9	10
High Slack	mean	4.69	4.09	5.06	4.61
	range	9.34	3.02	7.55	8.37
	min.	0.96	2.74	1.65	0.14
	max.	10.30	5.76	9.20	8.51
	std. dev.	3.41	1.08	2.31	2.32
	number	5	5	10	9
Ebb	mean	3.92	2.91	4.85	5.32
	range	4.94	3.85	5.48	8.33
	min.	2.33	1.37	2.20	2.47
	max.	7.27	5.22	7.68	10.80
	std. dev.	1.45	1.04	1.61	2.38
	number	13	13	12	14
Pore Water Drainage	mean	5.41			
	range	9.55			
	min.	1.65			
	max.	11.20			
	std. dev.	3.49			
	number	8			
All Samples	mean	4.85	3.64	5.54	4.94
	range	16.74	4.94	7.96	12.36
	min.	0.96	1.37	1.65	0.14
	max.	17.70	6.31	9.61	12.50
	std. dev.	3.28	1.30	1.96	2.58
	number	45	31	42	45

Table C'96

Tidal Statistics for Phaeophytin at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

PHAEOPHYTIN (µg/l)

		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Flood	mean	1.81	1.32	0.91	1.13
	range	7.05	2.30	1.90	1.81
	min.	0.58	0.58	0.38	0.48
	max.	7.63	2.88	2.28	2.29
	std. dev.	1.83	0.77	0.43	0.57
	number	16	15	20	20
High Slack	mean	0.85	0.60	0.77	0.69
	range	0.30	0.26	0.17	0.26
	min.	0.74	0.47	0.69	0.52
	max.	1.04	0.73	0.86	0.78
	std. dev.	0.13	0.18	0.07	0.15
	number	4	2	4	3
Ebb	mean	1.00	0.72	0.60	0.61
	range	2.47	0.66	0.30	0.36
	min.	0.38	0.41	0.45	0.41
	max.	2.85	1.07	0.75	0.77
	std. dev.	0.65	0.24	0.09	0.11
	number	12	8	16	17
Low Slack	mean	2.21		0.53	0.53
	range	3.50		0.22	0.29
	min.	0.75		0.40	0.44
	max.	4.25		0.62	0.73
	std. dev.	1.47		0.11	0.16
	number	4		4	5
Pore Water Drainage	mean	2.69			
	range	4.72			
	min.	1.00			
	max.	5.72			
	std. dev.	1.78			
	number	4			
Preprecipitational Ebb	mean		0.70	0.68	0.71
	range		0.09	0.27	0.18
	min.		0.66	0.58	0.62
	max.		0.75	0.85	0.80
	std. dev.		0.06	0.12	0.13
	number		2	4	2
All Samples	mean	1.96	1.22	0.74	0.83
	range	14.56	5.92	1.90	1.88
	min.	0.38	0.41	0.38	0.41
	max.	14.94	6.33	2.28	2.29
	std. dev.	2.49	1.17	0.31	0.45
	number	44	29	51	48

Table C'97

Tidal Statistics for Volatile Dissolved Organic Carbon at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

VOLATILE DISSOLVED ORGANIC CARBON (mg/l)					
		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Low Slack	mean	3.2		1.0	1.1
	range	8.2		1.4	2.2
	min.	0.8		0.6	0.4
	max.	9.0		2.0	2.6
	std. dev.	3.2		0.5	0.8
	number	6		8	7
Flood	mean	1.5	1.6	1.0	1.2
	range	2.0	2.5	2.5	1.8
	min.	0.7	0.3	0.0	0.2
	max.	2.7	2.8	2.5	2.0
	std. dev.	0.8	0.9	0.9	0.7
	number	8	8	10	10
High Slack	mean	4.1	1.5	1.2	1.7
	range	6.2	3.3	3.6	3.4
	min.	0.9	0.0	0.4	0.5
	max.	7.1	3.3	4.0	3.9
	std. dev.	2.6	1.4	1.1	1.2
	number	4	4	10	8
Ebb	mean	4.5	2.0	1.9	2.2
	range	10.3	4.5	6.3	4.5
	min.	0.4	0.4	0.4	0.0
	max.	10.7	4.9	6.7	4.5
	std. dev.	3.1	1.3	2.0	1.4
	number	11	12	11	11
Pore Water Drainage	mean	3.3			
	range	10.1			
	min.	0.1			
	max.	10.2			
	std. dev.	3.5			
	number	6			
All Samples	mean	3.2	1.7	1.3	1.6
	range	10.6	4.9	6.7	4.5
	min.	0.1	0.0	0.0	0.0
	max.	10.7	4.9	6.7	4.5
	std. dev.	2.8	1.1	1.5	1.2
	number	38	27	43	41

Table C'98

Tidal Statistics for Volatile Dissolved Organic Carbon at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

VOLATILE DISSOLVED ORGANIC CARBON (mg/l)

Tidal Stage		Artificial Marsh Pipe	Artificial Marsh Breach	Natural Marsh Large channel	Natural Marsh Small channel
Flood	mean	1.8	2.0	1.2	1.6
	range	1.8	3.0	1.8	2.1
	min.	1.0	1.0	0.3	0.7
	max.	2.8	4.0	2.1	2.8
	std. dev.	0.5	0.8	0.5	0.6
	number	16	16	19	20
High Slack	mean	1.8	0.9	0.9	1.5
	range	1.4	0.0	0.5	1.3
	min.	1.4	0.9	0.6	0.9
	max.	2.8	0.9	1.1	2.2
	std. dev.	0.6	0.0	0.2	0.6
	number	5	1	4	3
Ebb	mean	2.7	2.2	0.8	1.4
	range	3.5	1.4	1.3	1.8
	min.	1.0	1.5	0.2	0.7
	max.	4.5	2.9	1.5	2.5
	std. dev.	1.1	0.5	0.3	0.5
	number	14	8	17	18
Low Slack	mean	2.0		1.2	1.5
	range	1.7		0.7	1.8
	min.	0.9		0.8	0.5
	max.	2.6		1.5	2.3
	std. dev.	0.9		0.3	0.7
	number	3		4	5
Pore Water Drainage	mean	2.9			
	range	4.3			
	min.	0.8			
	max.	5.1			
	std. dev.	1.5			
	number	5			
Preprecipitational Ebb	mean		2.4	0.8	1.9
	range		0.7	0.2	0.3
	min.		2.1	0.7	1.7
	max.		2.8	0.9	2.0
	std. dev.		0.3	0.1	0.2
	number		4	3	3
All Samples	mean	2.2	2.0	1.0	1.5
	range	4.3	3.1	1.9	2.3
	min.	0.8	0.9	0.2	0.5
	max.	5.1	4.0	2.1	2.8
	std. dev.	1.0	0.7	0.4	0.5
	number	46	32	50	50

Table C'99

Tidal Statistics for Total Dissolved Organic Carbon at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

TOTAL DISSOLVED ORGANIC CARBON (mg/l)

		Artificial Marsh		Natural Marsh	
Tidal Stage		Pipe	Breach	Large channel	Small channel
Low Slack	mean	11.7		7.9	6.0
	range	9.1		18.7	5.4
	min.	6.7		2.7	3.9
	max.	15.8		21.4	9.3
	std. dev.	3.8		5.9	1.8
	number	6		8	7
Flood	mean	9.0	12.1	8.2	8.9
	range	9.2	29.8	24.1	23.2
	min.	3.6	3.3	2.1	1.5
	max.	12.8	33.1	26.2	24.7
	std. dev.	3.0	9.7	7.1	7.2
	number	8	8	10	10
High Slack	mean	10.3	6.2	10.3	9.4
	range	2.4	6.3	37.4	7.3
	min.	8.9	3.5	2.6	5.7
	max.	11.3	9.8	40.0	13.0
	std. dev.	1.0	2.7	10.9	2.8
	number	4	4	10	8
Ebb	mean	12.0	7.2	9.0	9.9
	range	19.2	7.6	11.4	24.4
	min.	5.6	4.5	4.7	3.2
	max.	24.8	12.1	16.1	27.6
	std. dev.	5.3	2.5	3.6	6.9
	number	11	12	11	11
Pore Water Drainage	mean	8.7			
	range	10.7			
	min.	4.2			
	max.	14.9			
	std. dev.	4.8			
	number	6			
All Samples	mean	10.5	8.9	8.9	8.7
	range	21.4	29.8	37.9	26.1
	min.	3.4	3.3	2.1	1.5
	max.	24.8	33.1	40.0	27.6
	std. dev.	4.5	5.9	6.9	5.3
	number	38	27	43	41

Table C'100

Tidal Statistics for Total Dissolved Organic Carbon at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

TOTAL DISSOLVED ORGANIC CARBON (mg/1)

Tidal Stage		Artificial Marsh		Natural Marsh	
		Pipe	Breach	Large channel	Small channel
Flood	mean	9.7	8.8	8.5	9.2
	range	10.4	12.9	16.4	9.7
	min.	5.1	3.8	2.1	4.5
	max.	15.5	16.7	18.5	14.2
	std. dev.	2.9	4.5	3.6	2.5
	number	16	16	19	20
High Slack	mean	8.7	7.2	8.0	6.7
	range	3.4	0.0	10.4	1.6
	min.	7.3	7.2	4.5	5.9
	max.	10.7	7.2	14.9	7.5
	std. dev.	1.2	0.0	4.7	0.8
	number	5	1	4	3
Ebb	mean	9.6	7.3	8.4	12.5
	range	9.9	4.7	9.5	19.7
	min.	4.9	4.5	4.8	6.0
	max.	14.8	9.2	14.3	25.7
	std. dev.	3.2	1.6	2.8	5.6
	number	14	8	17	19
Low Slack	mean	7.3		5.2	7.4
	range	0.4		4.2	2.8
	min.	7.1		3.5	5.5
	max.	7.5		7.7	8.3
	std. dev.	0.2		1.8	1.1
	number	3		4	5
Pore Water Drainage	mean	10.4			
	range	9.0			
	min.	6.3			
	max.	15.3			
	std. dev.	3.4			
	number	5			
Preprecipitational Ebb	mean		9.8	6.9	12.0
	range		8.7	2.9	4.8
	min.		4.2	5.3	9.5
	max.		12.9	8.2	14.3
	std. dev.		3.9	1.5	2.4
	number		4	3	3
All Samples	mean	9.6	8.6	8.0	10.2
	range	10.6	12.9	16.4	21.2
	min.	4.9	3.8	2.1	4.5
	max.	15.5	16.7	18.5	25.7
	std. dev.	2.9	3.8	3.2	4.3
	number	46	32	50	51

Table C'101

Tidal Statistics for Particulate Carbon at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977*

PARTICULATE CARBON (mg/l)

		Artificial Marsh		Natural Marsh	
Tidal Stage		**Pipe**	**Breach**	**Large channel**	**Small channel**
Flood	mean	3.09	2.04	1.52	1.88
	range	12.46	3.71	3.80	6.95
	min.	0.96	0.55	0.41	0.73
	max.	13.42	4.26	4.21	7.68
	std. dev.	3.26	1.20	0.93	1.69
	number	16	15	20	21
High Slack	mean	1.54	1.30	1.50	1.65
	range	1.71	0.44	1.17	1.57
	min.	0.95	1.08	1.00	1.02
	max.	2.66	1.52	2.17	2.59
	std. dev.	0.76	0.31	0.49	0.83
	number	4	2	4	3
Ebb	mean	1.38	1.23	1.10	1.49
	range	2.69	1.40	1.15	5.21
	min.	0.60	0.48	0.80	0.70
	max.	3.29	1.88	1.95	5.91
	std. dev.	0.66	0.46	0.27	1.21
	number	14	8	17	18
Low Slack	mean	3.16		0.98	1.19
	range	5.23		0.59	1.31
	min.	1.18		0.67	0.61
	max.	6.41		1.26	1.92
	std. dev.	2.27		0.24	0.58
	number	4		4	5
Pore Water Drainage	mean	6.04			
	range	12.40			
	min.	1.66			
	max.	14.06			
	std. dev.	5.07			
	number	5			
Preprecipitational Ebb	mean		1.16	1.93	1.27
	range		0.90	2.90	0.48
	min.		0.83	1.00	1.11
	max.		1.73	3.90	1.59
	std. dev.		0.42	1.33	0.27
	number		4	4	3
All Samples	mean	3.49	1.75	1.33	1.62
	range	34.13	4.65	3.80	7.07
	min.	0.60	0.48	0.41	0.61
	max.	34.73	5.13	4.21	7.68
	std. dev.	5.54	1.14	0.74	1.32
	number	46	31	52	51

* Data for August sampling period not available

Table C'102

Tidal Statistics for Dissolved Calcium at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

		DISSOLVED CALCIUM (mg/1)							
		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Low Slack	mean	18.0	18.1			15.5	13.6	13.4	12.6
	range	5.3	11.8			4.8	1.9	2.6	5.2
	min.	16.2	10.6			12.0	12.6	12.2	9.7
	max.	21.5	22.4			16.8	14.5	14.8	14.9
	std. dev.	2.6	4.2			1.5	0.8	1.1	2.1
	number	6	6			8	8	6	7
Flood	mean	15.8	15.5	14.8	14.8	14.8	12.6	13.6	13.6
	range	9.3	15.3	2.1	7.1	7.4	3.4	4.4	4.5
	min.	13.1	8.0	13.8	10.3	9.3	10.5	10.2	10.7
	max.	22.4	23.3	15.9	17.4	16.7	13.9	14.6	15.2
	std. dev.	2.5	3.8	0.8	2.3	2.2	1.0	1.3	1.4
	number	10	10	10	10	10	9	10	9
High Slack	mean	14.6	15.5	14.8	15.0	15.6	12.7	13.1	14.0
	range	2.5	2.1	1.0	2.5	6.9	6.9	3.0	4.3
	min.	13.1	14.5	14.4	13.6	9.8	7.3	11.0	11.6
	max.	15.6	16.6	15.4	16.1	16.7	14.2	14.0	15.9
	std. dev.	1.1	0.9	0.4	1.0	2.1	2.0	1.0	1.3
	number	5	5	5	5	10	10	10	10
Ebb	mean	16.0	16.9	14.9	16.0	15.7	13.2	13.2	13.1
	range	8.4	6.9	8.4	3.1	4.8	5.5	4.0	5.8
	min.	11.8	13.6	9.5	14.7	12.1	10.1	10.4	9.7
	max.	20.2	20.5	17.9	17.8	16.9	15.6	14.4	15.5
	std. dev.	2.0	1.9	2.2	1.1	1.3	1.4	1.4	1.9
	number	13	14	11	12	15	15	12	13
Pore Water Drainage	mean	19.6	21.0						
	range	4.1	2.7						
	min.	17.1	19.8						
	max.	21.2	22.5						
	std. dev.	1.6	1.0						
	number	8	7						
All Samples	mean	16.8	17.2	15.0	15.4	15.4	12.9	13.2	13.2
	range	10.6	15.3	8.4	7.5	7.6	8.3	4.6	6.2
	min.	11.8	8.0	9.5	10.3	9.3	7.3	10.2	9.7
	max.	22.4	23.3	17.9	17.8	16.9	15.6	14.8	15.9
	std. dev.	2.6	3.2	1.4	1.6	1.7	1.4	1.1	1.7
	number	45	45	30	31	47	48	44	44

Table C'103

Tidal Statistics for Dissolved Calcium at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

DISSOLVED CALCIUM (mg/l)

		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Flood	mean	13.9	11.9	14.1	13.3	11.3	12.0	11.6	12.0
	range	7.1	6.2	6.4	4.9	6.6	3.2	9.4	3.0
	min.	11.2	7.8	9.8	10.4	7.0	9.9	3.6	10.2
	max.	18.3	14.0	16.2	15.3	13.6	13.1	13.0	13.2
	std. dev.	1.6	1.6	1.3	1.5	1.8	0.9	2.0	0.8
	number	17	16	16	12	20	18	22	21
High Slack	mean	13.9	12.9	14.6	12.1	9.7	12.2	12.6	12.4
	range	1.6	0.7	0.3	2.6	6.0	1.5	0.6	1.5
	min.	13.1	12.4	14.4	10.8	7.1	11.3	12.3	11.5
	max.	14.7	13.1	14.7	13.4	13.1	12.8	12.9	13.0
	std. dev.	0.6	0.3	0.2	1.8	2.2	0.6	0.3	0.8
	number	5	5	2	2	5	5	3	3
Ebb	mean	14.4	13.4	14.8	14.0	11.0	11.41	11.6	11.9
	range	7.7	8.0	2.5	5.2	5.8	8.5	2.8	3.2
	min.	10.7	9.2	13.8	10.6	7.5	4.0	10.2	9.8
	max.	18.4	17.2	16.3	15.8	13.3	12.5	13.0	13.0
	std. dev.	2.4	2.2	0.9	1.5	1.5	2.1	0.7	0.9
	number	14	14	8	8	17	17	18	16
Low Slack	mean	15.0	11.7			10.5	11.7	11.8	12.0
	range	6.4	3.6			1.9	2.4	3.2	2.9
	min.	12.1	10.0			9.2	10.0	9.8	10.0
	max.	18.5	13.6			11.1	12.4	13.0	12.9
	std. dev.	3.1	1.5			0.9	1.2	1.3	1.2
	number	4	4			4	4	5	5
Pore Water Drainage	mean	15.7	12.3						
	range	5.0	6.1						
	min.	12.6	9.3						
	max.	17.6	15.4						
	std. dev.	2.1	2.5						
	number	5	5						
Preprecipitational Ebb	mean			13.0	11.2	11.4	12.0	12.6	11.7
	range			1.8	4.5	3.9	1.3	0.1	2.2
	min.			12.1	9.1	9.8	11.4	12.6	10.8
	max.			13.9	13.6	13.7	12.7	12.7	13.0
	std. dev.			0.7	2.4	1.7	0.6	0.0	1.1
	number			4	4	4	4	3	d
All Samples	mean	14.3	12.4	14.2	13.1	11.0	11.8	11.8	12.0
	range	7.8	9.4	6.5	7.0	6.7	9.1	9.5	3.4
	min.	10.7	7.8	9.8	8.8	7.0	4.0	3.6	9.8
	max.	18.5	17.2	16.3	15.8	13.7	13.1	13.1	13.2
	std. dev.	1.9	1.9	1.2	1.9	1.6	1.4	1.4	0.9
	number	48	46	31	32	53	51	52	49

Table C'104

Tidal Statistics for Dissolved Iron at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

DISSOLVED IRON (mg/l)

		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Low Slack	mean	0.881	0.652			0.313	0.364	0.331	0.286
	range	2.088	1.756			0.495	0.183	0.266	0.175
	min.	0.212	0.164			0.100	0.263	0.170	0.214
	max.	2.300	1.920			0.595	0.446	0.436	0.389
	std. dev.	0.766	0.661			0.150	0.059	0.094	0.058
	number	6	6			8	8	6	7
Flood	mean	0.533	0.453	0.254	0.192	0.299	0.245	0.269	0.232
	range	2.093	1.998	0.471	0.334	0.309	0.270	0.331	0.222
	min.	0.107	0.062	0.112	0.048	0.159	0.138	0.074	0.131
	max.	2.200	2.060	0.583	0.382	0.468	0.408	0.405	0.353
	std. dev.	0.628	0.606	0.132	0.122	0.081	0.096	0.122	0.074
	number	10	10	10	10	10	9	10	9
High Slack	mean	0.186	0.246	0.245	0.208	0.231	0.198	0.166	0.205
	range	0.217	0.184	0.182	0.227	0.230	0.101	0.166	0.215
	min.	0.091	0.159	0.172	0.093	0.125	0.149	0.084	0.104
	max.	0.308	0.343	0.354	0.320	0.355	0.250	0.250	0.319
	std. dev.	0.098	0.073	0.074	0.086	0.069	0.034	0.062	0.063
	number	5	5	5	5	10	10	10	10
Ebb	mean	0.419	0.708	0.319	0.439	0.284	0.313	0.346	0.306
	range	0.982	1.605	0.557	0.967	0.338	0.386	0.390	0.411
	min.	0.078	0.155	0.126	0.163	0.117	0.116	0.187	0.113
	max.	1.060	1.760	0.683	1.130	0.455	0.502	0.577	0.524
	std. dev.	0.307	0.446	0.174	0.262	0.105	0.119	0.112	0.109
	number	13	13	13	12	15	15	12	13
Pore Water Drainage	mean	1.081	1.374						
	range	2.347	3.719						
	min.	0.313	0.341						
	max.	2.660	4.060						
	std. dev.	0.835	1.349						
	number	8	7						
All Samples	mean	0.588	0.663	0.296	0.296	0.277	0.275	0.270	0.252
	range	2.582	3.998	0.571	1.082	0.516	0.386	0.503	0.420
	min.	0.078	0.062	0.112	0.048	0.079	0.116	0.074	0.104
	max.	2.660	4.060	0.683	1.130	0.595	0.502	0.577	0.524
	std. dev.	0.615	0.752	0.147	0.211	0.105	0.103	0.114	0.090
	number	45	44	32	31	47	48	44	44

Table C'105

Tidal Statistics for Dissolved Iron at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

DISSOLVED IRON (mg/l)

		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Flood	mean	0.255	0.265	0.250	0.259	0.262	0.348	0.315	0.312
	range	0.630	0.609	0.900	0.490	0.450	0.454	0.458	0.541
	min.	0.090	0.049	0.060	0.070	0.070	0.134	0.142	0.137
	max.	0.720	0.658	0.960	0.560	0.520	0.588	0.600	0.678
	std. dev.	0.162	0.189	0.231	0.165	0.121	0.119	0.140	0.151
	number	17	16	16	16	20	18	20	21
High Slack	mean	0.214	0.264	0.290	0.300	0.302	0.285	0.408	0.358
	range	0.210	0.302	0.440	0.420	0.350	0.341	0.567	0.198
	min.	0.090	0.099	0.070	0.090	0.070	0.180	0.089	0.243
	max.	0.300	0.401	0.510	0.510	0.420	0.521	0.656	0.441
	std. dev.	0.084	0.109	0.311	0.297	0.145	0.140	0.290	0.103
	number	5	5	2	2	5	5	3	3
Ebb	mean	0.294	0.176	0.239	0.274	0.323	0.247	0.298	0.320
	range	0.870	0.447	0.550	0.450	0.340	0.344	0.217	0.354
	min.	0.070	0.041	0.040	0.060	0.160	0.097	0.179	0.104
	max.	0.940	0.488	0.590	0.510	0.500	0.441	0.396	0.458
	std. dev.	0.252	0.120	0.205	0.176	0.094	0.092	0.064	0.093
	number	14	14	8	8	17	17	18	16
Low Slack	mean	0.500	0.446			0.315	0.367	0.325	0.282
	range	0.390	0.714			0.190	0.112	0.297	0.376
	min.	0.390	0.066			0.220	0.310	0.175	0.120
	max.	0.780	0.774			0.410	0.422	0.472	0.496
	std. dev.	0.187	0.309			0.083	0.051	0.120	0.152
	number	4	4			4	4	5	5
Pore Water Drainage	mean	0.720	0.260						
	range	2.680	0.748						
	min.	0.060	0.066						
	max.	2.740	0.814						
	std. dev.	1.135	0.311						
	number	5	5						
Preprecipitational Ebb	mean			0.238	0.270	0.203	0.253	0.243	0.110
	range			0.330	0.130	0.190	0.234	0.299	0.114
	min.			0.050	0.220	0.090	0.124	0.097	0.072
	max.			0.380	0.350	0.280	0.358	0.396	0.186
	std. dev.			0.156	0.057	0.082	0.098	0.150	0.066
	number			4	4	4	4	3	3
All Samples	mean	0.326	0.248	0.251	0.290	0.285	0.293	0.316	0.302
	range	2.690	0.773	0.920	1.110	0.450	0.491	0.567	0.606
	min.	0.050	0.041	0.040	0.060	0.070	0.097	0.089	0.072
	max.	2.740	0.814	0.960	1.170	0.520	0.588	0.656	0.678
	std. dev.	0.405	0.195	0.207	0.224	0.110	0.115	0.130	0.132
	number	48	46	31	32	53	51	50	49

Table C'106

Tidal Statistics for Dissolved Manganese at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

DISSOLVED MANGANESE (mg/l)

		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Low Slack	mean	0.280	0.310			0.052	0.052	0.059	0.048
	range	0.503	0.672			0.057	0.071	0.049	0.051
	min.	0.067	0.062			0.029	0.027	0.023	0.034
	max.	0.570	0.734			0.086	0.098	0.072	0.085
	std. dev.	0.025	0.273			0.019	0.022	0.018	0.018
	number	6	6			7	8	6	7
Flood	mean	0.228	0.112	0.106	0.044	0.040	0.037	0.044	0.037
	range	1.712	0.713	0.204	0.076	0.047	0.036	0.068	0.034
	min.	0.018	0.014	0.047	0.011	0.013	0.018	0.011	0.019
	max.	1.730	0.727	0.251	0.087	0.060	0.054	0.079	0.053
	std. dev.	0.529	0.218	0.059	0.025	0.012	0.013	0.023	0.012
	number	10	10	10	9	10	9	10	9
High Slack	mean	0.040	0.041	0.126	0.020	0.035	0.030	0.036	0.038
	range	0.057	0.029	0.139	0.014	0.034	0.022	0.098	0.033
	min.	0.018	0.033	0.073	0.013	0.018	0.020	0.018	0.020
	max.	0.075	0.062	0.212	0.027	0.052	0.042	0.116	0.053
	std. dev.	0.023	0.012	0.056	0.006	0.012	0.008	0.029	0.011
	number	5	5	5	5	10	10	10	10
Ebb	mean	0.154	0.155	0.293	0.103	0.052	0.056	0.063	0.067
	range	0.324	0.321	0.595	0.141	0.068	0.069	0.102	0.129
	min.	0.055	0.048	0.049	0.027	0.018	0.016	0.024	0.020
	max.	0.379	0.369	0.644	0.168	0.086	0.085	0.126	0.149
	std. dev.	0.107	0.097	0.177	0.039	0.025	0.019	0.029	0.033
	number	13	14	13	12	15	15	12	12
Pore Water Drainage	mean	0.454	0.486						
	range	0.266	0.205						
	min.	0.302	0.384						
	max.	0.568	0.589						
	std. dev.	0.092	0.070						
	number	8	7						
All Samples	mean	0.229	0.206	0.200	0.067	0.044	0.044	0.049	0.048
	range	1.712	0.720	0.597	0.157	0.079	0.082	0.115	0.138
	min.	0.018	0.014	0.047	0.011	0.007	0.016	0.011	0.011
	max.	1.730	0.734	0.644	0.168	0.086	0.098	0.126	0.149
	std. dev.	0.291	0.209	0.150	0.045	0.020	0.019	0.027	0.026
	number	45	45	32	30	46	48	44	43

Table C'107

Tidal Statistics for Dissolved Manganese at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

DISSOLVED MANGANESE (mg/l)

		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Flood	mean	0.054	0.047	0.038	0.033	0.029	0.030	0.025	0.027
	range	0.330	0.269	0.123	0.072	0.024	0.035	0.021	0.032
	min.	0.019	0.015	0.020	0.016	0.018	0.012	0.018	0.016
	max.	0.349	0.284	0.143	0.088	0.042	0.047	0.039	0.048
	std. dev.	0.077	0.064	0.029	0.016	0.007	0.009	0.006	0.007
	number	17	16	16	16	20	18	21	21
High Slack	mean	0.031	0.025	0.023	0.025	0.020	0.022	0.025	0.023
	range	0.012	0.014	0.006	0.011	0.011	0.013	0.017	0.004
	min.	0.027	0.017	0.020	0.020	0.015	0.017	0.016	0.020
	max.	0.039	0.031	0.026	0.031	0.026	0.030	0.033	0.024
	std. dev.	0.005	0.006	0.004	0.008	0.005	0.006	0.009	0.002
	number	5	5	2	2	5	5	3	3
Ebb	mean	0.093	0.082	0.048	0.049	0.031	0.027	0.028	0.033
	range	0.313	0.247	0.046	0.061	0.040	0.025	0.022	0.036
	min.	0.025	0.017	0.026	0.020	0.014	0.017	0.021	0.020
	max.	0.338	0.264	0.072	0.081	0.054	0.042	0.043	0.056
	std. dev.	0.098	0.078	0.016	0.020	0.010	0.007	0.007	0.009
	number	14	14	8	8	17	17	18	16
Low Slack	mean	0.147	0.113			0.041	0.045	0.050	0.045
	range	0.275	0.207			0.011	0.020	0.020	0.022
	min.	0.050	0.039			0.036	0.036	0.043	0.030
	max.	0.325	0.246			0.047	0.056	0.063	0.052
	std. dev.	0.122	0.091			0.005	0.008	0.008	0.009
	number	4	4			4	4	5	5
Pore Water Drainage	mean	0.193	0.148						
	range	0.348	0.328						
	min.	0.042	0.027						
	max.	0.390	0.355						
	std. dev.	0.162	0.125						
	number	5	5						
Preprecipitational Ebb	mean			0.028	0.028	0.023	0.021	0.019	0.016
	range			0.008	0.004	0.011	0.006	0.004	0.008
	min.			0.024	0.026	0.019	0.019	0.017	0.012
	max.			0.032	0.030	0.030	0.025	0.021	0.020
	std. dev.			0.003	0.002	0.005	0.003	0.002	0.004
	number			4	4	4	4	3	3
All Samples	mean	0.084	0.071	0.038	0.036	0.029	0.029	0.029	0.030
	range	0.371	0.340	0.123	0.072	0.040	0.044	0.047	0.044
	min.	0.019	0.015	0.020	0.016	0.014	0.012	0.016	0.012
	max.	0.390	0.355	0.143	0.088	0.054	0.056	0.063	0.056
	std. dev.	0.101	0.080	0.023	0.018	0.009	0.009	0.010	0.010
	number	48	46	31	32	53	51	51	49

Table C'108

Tidal Statistics for Dissolved Mercury at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

DISSOLVED MERCURY* (µg/l)

		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Low Slack	mean	0.87	0.73	Breach dry		0.84	0.82	1.26	0.60
	range	1.56	1.01			1.09	0.96	2.88	0.32
	min.	0.29	0.31	during		0.44	0.53	0.41	0.42
	max.	1.85	1.32			1.53	1.49	3.29	0.74
	std. dev.	0.71	0.48	low slack		0.50	0.45	1.36	0.13
	number	4	4			4	4	4	4
Flood	mean	0.57	0.62	0.49	0.48	0.40	0.39	0.46	0.47
	range	0.36	0.36	0.26	0.22	0.11	0.08	0.38	0.38
	min.	0.40	0.42	0.38	0.36	0.34	0.34	0.30	0.34
	max.	0.76	0.78	0.64	0.58	0.45	0.42	0.68	0.72
	std. dev.	0.16	0.18	0.11	0.09	0.05	0.04	0.17	0.17
	number	4	4	4	4	4	4	4	4
High Slack	mean	1.00	0.70	0.56	0.55	0.46	0.55	0.52	0.42
	range	1.21	0.50	0.53	0.42	0.30	0.34	0.45	0.03
	min.	0.57	0.37	0.31	0.30	0.34	0.36	0.33	0.41
	max.	1.78	0.87	0.84	0.72	0.64	0.70	0.78	0.44
	std. dev.	0.53	0.28	0.27	0.19	0.14	0.15	0.19	0.02
	number	4	3	3	4	4	4	4	4
Ebb	mean	0.37	0.42	0.46	0.73	0.52	0.52	0.46	1.02
	range	0.21	0.22	0.25	1.26	0.29	0.25	0.29	2.20
	min.	0.23	0.32	0.38	0.38	0.38	0.40	0.31	0.28
	max.	0.44	0.54	0.63	1.64	0.67	0.65	0.60	2.48
	std. dev.	0.09	0.09	0.11	0.60	0.13	0.12	0.14	1.01
	number	4	4	4	4	4	4	4	4
Pore Water Drainage	mean	0.55	0.55						
	range	0.32	0.16						
	min.	0.42	0.45						
	max.	0.74	0.61						
	std. dev.	0.17	0.07						
	number	3	4						
All Samples	mean	0.68	0.60	0.50	0.59	0.55	0.57	0.68	0.63
	range	1.62	1.01	0.53	1.33	1.19	1.15	2.99	2.20
	min.	0.23	0.31	0.31	0.30	0.34	0.34	0.30	0.28
	max.	1.85	1.32	0.84	1.64	1.53	1.49	3.29	2.48
	std. dev.	0.45	0.26	0.15	0.35	0.30	0.28	0.71	0.52
	number	19	19	11	12	16	16	16	16

* Analysis conducted on composited samples; other metal statistics calculated from water samples collected and analyzed on an hourly basis

Table C'109

Tidal Statistics for Dissolved Mercury* at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

DISSOLVED MERCURY* (µg/l)

		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Flood	mean	0.230	0.22	0.30	0.31	0.19	0.19	0.23	0.35
	range	0.133	0.13	0.23	0.26	0.06	0.09	0.11	0.46
	min.	0.175	0.17	0.24	0.23	0.16	0.14	0.16	0.20
	max.	0.300	0.30	0.47	0.49	0.22	0.23	0.28	0.66
	std. dev.	0.049	0.05	0.10	0.11	0.02	0.04	0.04	0.19
	number	5	5	5	5	5	5	5	5
High Slack	mean	0.295	0.31	0.39	0.30	0.22	0.22	0.22	0.31
	range	0.124	0.16	0.10	0.21	0.03	0.11	0.02	0.10
	min.	0.244	0.26	0.34	0.19	0.21	0.16	0.21	0.26
	max.	0.368	0.42	0.44	0.40	0.24	0.27	0.23	0.36
	std. dev.	0.065	0.09	0.07	0.15	0.02	0.05	0.02	0.07
	number	3	3	2	2	3	3	2	2
Ebb	mean	0.219	0.22	0.58	0.60	0.18	0.18	0.23	0.24
	range	0.066	0.04	1.10	1.16	0.11	0.11	0.15	0.08
	min.	0.187	0.20	0.21	0.21	0.13	0.12	0.12	0.20
	max.	0.253	0.23	1.31	1.37	0.24	0.23	0.27	0.28
	std. dev.	0.033	0.02	0.63	0.67	0.05	0.04	0.07	0.04
	number	4	4	3	3	4	4	4	4
Low Slack	mean	0.368	0.34			0.71	0.74	0.20	0.29
		0.253	0.18			0.79	0.70	0.07	0.14
		0.256	0.25			0.36	0.39	0.16	0.22
	max.	0.509	0.43			1.05	1.09	0.23	0.36
	std. dev.	0.125	0.10			0.49	0.50	0.05	0.10
	number	4	4			2	2	2	2
Pore Water Drainage	mean	0.337	0.34						
	range	0.227	0.28						
	min.	0.250	0.23						
	max.	0.477	0.51						
	std. dev.	0.099	0.12						
	number	4	4						
Preprecipi-tational Ebb	mean			0.25	0.24	0.31	0.33	0.16	0.35
	range			---	---	---	---	---	---
	min.			---	---	---	---	---	---
	max.			---	---	---	---	---	---
	std. dev.			---	---	---	---	---	---
	number			1	1	1	1	1	1
All Samples	mean	0.286	0.28	0.39	0.38	0.27	0.28	0.22	0.30
	range	0.334	0.34	1.10	1.18	0.92	0.96	0.16	0.46
	min.	0.175	0.17	0.21	0.18	0.13	0.12	0.12	0.20
	max.	0.509	0.51	1.31	1.37	1.05	1.09	0.28	0.66
	std. dev.	0.094	0.09	0.32	0.34	0.22	0.24	0.05	0.12
	number	20	20	11	11	15	15	14	14

* Analysis conducted on composited samples; other metal statistics calculated from water samples collected and analyzed on an hourly basis

Table C'110

Tidal Statistics for Dissolved Zinc at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, August 5-7, 1976

		DISSOLVED ZINC (mg/l)							
		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Low Slack	mean	0.052	0.109			0.099	0.099	0.103	0.079
	range	0.063	0.126			0.308	0.233	0.126	0.081
	min.	0.032	0.044			0.016	0.034	0.055	0.047
	max.	0.095	0.170			0.324	0.267	0.181	0.128
	std. dev.	0.023	0.043			0.096	0.078	0.055	0.030
	number	6	6			8	8	6	7
Flood	mean	0.077	0.065	0.093	0.116	0.055	0.078	0.084	0.047
	range	0.153	0.122	0.103	0.111	0.061	0.106	0.130	0.051
	min.	0.025	0.032	0.042	0.084	0.031	0.046	0.028	0.024
	max.	0.178	0.154	0.145	0.195	0.092	0.152	0.158	0.075
	std. dev.	0.052	0.034	0.037	0.039	0.018	0.035	0.039	0.017
	number	10	10	10	10	10	9	10	9
High Slack	mean	0.059	0.057	0.090	0.123	0.058	0.083	0.062	0.090
	range	0.084	0.050	0.167	0.160	0.108	0.196	0.063	0.168
	min.	0.033	0.026	0.042	0.061	0.016	0.030	0.030	0.028
	max.	0.117	0.076	0.209	0.221	0.124	0.226	0.093	0.196
	std. dev.	0.034	0.019	0.068	0.069	0.032	0.066	0.021	0.061
	number	5	5	5	5	10	10	10	10
Ebb	mean	0.084	0.061	0.100	0.128	0.068	0.109	0.092	0.082
	range	0.221	0.154	0.148	0.198	0.164	0.175	0.148	0.116
	min.	0.039	0.019	0.042	0.045	0.031	0.054	0.044	0.032
	max.	0.260	0.173	0.190	0.243	0.195	0.229	0.192	0.148
	std. dev.	0.057	0.044	0.047	0.063	0.041	0.047	0.043	0.041
	number	13	12	13	12	15	15	12	13
Pore Water Drainage	mean	0.080	0.062						
	range	0.092	0.093						
	min.	0.041	0.024						
	max.	0.133	0.117						
	std. dev.	0.030	0.029						
	number	8	7						
All Samples	mean	0.074	0.067	0.092	0.132	0.066	0.092	0.083	0.072
	range	0.235	0.154	0.177	0.495	0.308	0.237	0.164	0.172
	min.	0.025	0.019	0.032	0.045	0.016	0.030	0.028	0.024
	max.	0.260	0.173	0.209	0.540	0.324	0.267	0.192	0.196
	std. dev.	0.044	0.038	0.046	0.089	0.040	0.054	0.040	0.042
	number	45	43	32	31	47	48	44	44

Table C'111

Tidal Statistics for Dissolved Zinc at the Channels to the James River Artificial Habitat Development Site and a Natural Reference Marsh, January 8-10, 1977

DISSOLVED ZINC (mg/l)

		Artificial Marsh				Natural Marsh			
		Pipe		Breach		Large channel		Small channel	
Tidal Stage		alpha	beta	alpha	beta	alpha	beta	alpha	beta
Flood	mean	0.090	0.061	0.052	0.074	0.085	0.047	0.034	0.030
	range	0.130	0.082	0.122	0.107	0.153	0.072	0.072	0.053
	min.	0.035	0.032	0.018	0.038	0.024	0.024	0.016	0.008
	max.	0.165	0.114	0.140	0.145	0.177	0.096	0.088	0.061
	std. dev.	0.037	0.025	0.036	0.029	0.039	0.017	0.017	0.018
	number	17	17	16	16	20	18	22	22
High Slack	mean	0.087	0.049	0.031	0.078	0.067	0.049	0.032	0.038
	range	0.132	0.039	0.013	0.008	0.082	0.029	0.030	0.070
	min.	0.033	0.027	0.024	0.074	0.022	0.035	0.018	0.013
	max.	0.165	0.066	0.037	0.082	0.104	0.064	0.043	0.083
	std. dev.	0.048	0.010	0.009	0.006	0.029	0.011	0.015	0.039
	number	5	5	2	2	5	5	3	3
Ebb	mean	0.076	0.045	0.037	0.074	0.076	0.036	0.036	0.038
	range	0.130	0.074	0.055	0.117	0.116	0.061	0.062	0.065
	min.	0.035	0.017	0.016	0.035	0.018	0.014	0.011	0.009
	max.	0.165	0.091	0.071	0.152	0.134	0.075	0.073	0.074
	std. dev.	0.040	0.018	0.018	0.040	0.030	0.016	0.018	0.020
	number	14	14	8	8	17	17	18	17
Low Slack	mean	0.101	0.087			0.086	0.053	0.038	0.019
	range	0.175	0.115			0.066	0.050	0.033	0.022
	min.	0.032	0.049			0.057	0.026	0.024	0.011
	max.	0.207	0.164			0.123	0.076	0.057	0.033
	std. dev.	0.077	0.053			0.031	0.022	0.013	0.009
	number	4	4			4	4	5	5
Pore Water Drainage	mean	0.089	0.062						
	range	0.106	0.052						
	min.	0.027	0.036						
	max.	0.133	0.088						
	std. dev.	0.043	0.019						
	number	5	5						
Preprecipitational Ebb	mean			0.039	0.084	0.082	0.037	0.040	0.021
	range			0.048	0.037	0.076	0.033	0.013	0.035
	min.			0.016	0.062	0.055	0.018	0.033	0.006
	max.			0.064	0.099	0.131	0.051	0.046	0.041
	std. dev.			0.025	0.016	0.035	0.016	0.007	0.018
	number			4	4	4	4	3	3
All Samples	mean	0.086	0.058	0.045	0.075	0.080	0.043	0.035	0.031
	range	0.180	0.147	0.124	0.117	0.159	0.082	0.077	0.077
	min.	0.027	0.017	0.016	0.035	0.018	0.014	0.011	0.006
	max.	0.207	0.164	0.140	0.152	0.177	0.096	0.088	0.083
	std. dev.	0.042	0.028	0.029	0.029	0.033	0.017	0.016	0.020
	number	47	46	31	32	53	51	52	51

Table C'112

Statistics for the Mineralogy of the Clay and Silt Fractions for the Suspended Sediments at the Effluent Pipe of the Intertidal Diked Containment Area on the James River near Windmill Point During the Active Dredging Period and 3.5 Months Later

CLAY FRACTION (<2 μm)

Clay Mineral	Mean (%)	Standard Deviation	Range
Illite	47	3	43 - 50
Chlorite	24	5	20 - 31
Mixed-Layered Illite-Chlorite	6	4	11 - 22
Vermiculite	5	4	Tr - 9
Smectite	5	2	Tr - 8
Kaolinite	4	3	Tr - 7

SILT FRACTION (2-62 μm)

Mineral	Mean (%)	Standard Deviation	Range
Quartz	54	8	44 - 65
K-feldspar	16	2	13 - 18
Plagioclase Feldspar	13	2	10 - 15
Muscovite Mica	17	5	13 - 22
Amphibole	0.8	0.7	Tr - 2

Tr = less than one percent

Table C'113

Statistics for Size Analyses of the Suspended Material at the Effluent Pipe of the Intertidal Diked Containment Area on the James River near Windmill Point During the Dredging Period and 3.5 Months Later

	Active Dredging			May Tidal Period			Totals for All Samples		
	Mean	Standard Deviation	Range	Mean	Standard Deviation	Range	Mean	Standard Deviation	Range
Mean ϕ	7.7	0.6	7.0 - 8.7	8.7	1.1	6.4 - 9.6	8.1	1.0	6.4 - 9.6
Sorting Coefficient (ϕ)	2.9	0.3	2.3 - 3.3	2.5	0.3	1.9 - 2.9	2.7	0.4	1.9 - 3.3
Skewness	0.22	0.12	0.14 - 0.45	0.05	0.11	-0.13 - +0.21	0.14	0.14	-0.04 - +0.45
Kurtosis	-0.34	0.26	-0.57 - +0.27	-0.46	0.17	-0.63 - -0.13	-0.41	0.23	-0.63 - +0.27
Sand (%)	7.96	6.90	1.12 - 22.04	0.75	1.36	0.0 - 3.81	4.59	6.20	0.0 - 22.04
Silt (%)	51.67	8.28	39.83 - 67.36	43.61	17.23	22.94 - 68.21	47.91	13.38	22.94 - 68.21
Clay (%)	40.38	7.05	31.71 - 51.77	55.64	18.15	27.98 - 76.90	47.50	15.10	27.98 - 76.90
Mode 1 (ϕ)	5.08	1.03	3.71 - 7.00	6.28	1.23	5.01 - 7.69	5.64	1.25	3.71 - 7.69
Mode 2 (ϕ)	7.20	1.31	5.48 - 9.43	8.52	1.20	7.15 - 9.39	7.64	1.37	5.48 - 9.43
Mode 3 (ϕ)	9.41	0.06	9.36 - 9.48	9.91	--	--	9.54	0.26	9.36 - 9.91
Conc. (g/l)	144.6	121.9	11 - 320	8.1	15.1	0.7 - 39	70.12	105.6	0.447 - 320

Table C' 114

Statistics for Cation Exchange Capacity and Mineralogy† of the Suspended Sediments at the Effluent Pipe of the Intertidal Diked Containment Area on the James River near Windmill Point During the Active Dredging Period and 3.5 Months Later

Parameter*	Mean	Standard Deviation	Range**
CaEC UNT (meq/100 g)	31.0	8.7	29.3 - 43.8
CaEC Cleaned (meq/100 g)	27.2	25.6	19.7 - 88.4
K/EC UNT (meq/100 g)	11.7	2.3	10.3 - 15.2
K/EC Cleaned (meq/100 g)	17.5	8.0	7.4 - 27.8
Quartz (%)†	28	7	22 - 37
Plagioclase Feldspar (%)	7	3	4 - 11
K-Feldspar (%)	8	3	6 - 12
Muscovite Mica (%)	9	4	5 - 13
Illite (%)	23	7	13 - 32
Kaolinite (%)	2	2	Tr - 4
Smectite (%)	2	1	1 - 4
Vermiculite (%)	2	2	Tr - 4
Mixed-Layered Illite-Chlorite (%)	8	4	3 - 12
Chlorite (%)	11	3	7 - 15

* CaEC UNT = less than 2 μm fraction untreated
CaEC Cleaned = less than 2 μm fraction with organic matter and iron oxide coatings removed
K/EC UNT = less than 2 μm fraction untreated
K/EC Cleaned = less than 2 μm fraction with organic matter and iron oxide coatings removed

** Tr = less than one percent

† Mineralogy is based on the weight percent of the total sediment

Table C'115

Summary Statistics for Sediment Size Parameters for Cores Collected from the Reference Marsh in August 1976

Summary of size analysis statistics for upper, middle and lower sections of cores

Core Section		Mean Size (ϕ)	Sorting Coefficient (ϕ)	Skewness	Kurtosis	Sand (%)	Silt (%)	Clay (%)	Modes (ϕ) 1	2	3
Upper	Mean	8.3580	3.3820	-0.1440	-0.3694	13.3537	33.5100	52.7587	3.76	6.79	
	Std. Dev.	1.2799	0.8872	0.3016	0.4176	15.5303	11.1873	7.587	3.89	1.56	
	Range	6.8636-10.1987	2.3906-4.4627	-0.6913-0.2088	-0.6983-0.5598	0.23-33.70	19.17-43.13	43.84-61.08	-2.49-7.41	4.77-7.97	
Middle	Mean	9.3837	2.5404	-0.1006	0.0237	1.349	32.945	65.7080	7.55	---	
	Std. Dev.	0.2535	0.0692	0.1378	0.50	0.7844	6.6445	6.1854	0.42	---	
	Range	8.9404-9.6820	2.4771-2.7207	-0.2683-0.0553	-0.5470-0.6994	0.21-2.40	24.8-42.61	56.36-73.27	6.89-8.08	---	
Lower	Mean	9.0567	2.7975	-0.2052	0.1769	4.1837	32.887	62.93	7.84	3.75	
	Std. Dev.	0.3433	0.5507	0.2357	0.4769	4.0275	2.9016	3.8141	0.64	2.73	
	Range	8.6202-9.5103	1.7548-3.4097	-0.4585-0.1317	-0.4428-0.8686	0.36-9.92	28.01-38.42	57.93-67.53	7.48-9.41	0.63-7.66	

Summary statistics for all sediment samples

		Mean Size (ϕ)	Sorting Coefficient (ϕ)	Skewness	Kurtosis	Sand (%)	Silt (%)	Clay (%)	Modes (ϕ) 1	2	3
	Mean	8.9682	2.8785	-0.15	-0.06	6.3	33.1	60.5	6.43	5.45	3.80
	Std. Dev.	0.8400	0.6603	0.05	0.28	6.3	0.3	6.8	2.85	2.80	2.15
	Range	6.8636-10.1987	1.7548-4.4627	-0.69-0.21	-0.70-0.87	0.21-33.70	19.2-43.1	43.8-73.3	-2.49-9.41	0.63-9.25	0.61-5.39

(continued)

Table C'115 (Concluded)

Summary statistics of size analysis for individual sites within the reference marsh

Core Section*		Mean Size (ϕ)	Sorting Coefficient (ϕ)	Skewness	Kurtosis	Sand (%)	Silt (%)	Clay (%)	Modes (ϕ) 1	Modes (ϕ) 2
RH-cores										
Upper 0 - 10 cm	Mean	6.9098	4.347	-0.0612	-0.6736	31.74	21.9966	45.2633	1.24	7.80
	Std. Dev.	0.645	0.1322	0.0104	0.0292	1.7116	2.7396	1.6892	0.08	0.15
	Range	6.8636- 6.9835	4.2032- 4.4627	-0.0724- -0.0516	-0.6983- -0.6413	30.54- 33.70	19.17- 24.64	43.84- 47.13	1.12- 1.33	7.69- 7.97
Middle 10 - 24 cm	Mean	9.5677	2.5093	-0.2543	0.5730	2.0966	26.0833	71.82	8.03	---
	Std. Dev.	0.1601	0.0360	0.0180	0.1107	0.2010	1.9935	2.1906	0.07	---
	Range	9.3846- 9.6820	2.4771- 2.5482	-0.2683- -0.2340	0.4292- 0.6994	1.93- 2.32	24.8- 28.38	69.3- 73.27	7.98- 8.08	---
Lower 24 - 50 cm	Mean	8.8091	3.2743	-0.3954	0.3100	8.57	30.8133	60.6233	7.62	1.05
	Std. Dev.	0.2836	0.162	0.0453	0.2209	1.7521	2.4283	4.1569	0.10	0.59
	Range	8.6202- 9.1353	3.0948- 3.4097	-0.4455- -0.3572	0.1161- 0.5505	6.59- 9.92	28.01- 32.27	57.92- 65.41	7.53- 7.73	0.63- 1.73
RI-cores										
Upper 0 - 10 cm	Mean	8.8744	2.6035	-0.2562	0.2033	5.29	39.53	59.81	2.45	---
	Std. Dev.	0.3340	0.1063	0.3713	0.5040	5.5154	0.2121	1.2303	6.98	---
	Range	8.6382- 9.1106	2.5771- 3.6579	-0.5188- 0.0064	-0.1531- 0.5598	1.39- 9.19	30.13- 39.68	58.94- 60.68	-2.49- 7.38	---
Middle 10 - 24 cm	Mean	9.0779	2.6045	-0.0124	-0.1670	1.3266	39.74	58.9366	7.27	---
	Std. Dev.	0.1791	0.1060	0.0432	0.3292	0.4966	2.708	2.6859	0.33	---
	Range	8.9404- 9.2805	2.5129- 2.7207	-0.0574- 0.0289	-0.4094- 0.2078	1.03- 1.90	37.23- 42.61	56.36- 61.72	6.89- 7.47	---
Lower 24 - 50 cm	Mean	9.2041	2.8736	-0.2819	0.3637	3.14	33.735	63.12	7.59	---
	Std. Dev.	0.3596	0.3795	0.2496	0.7139	2.5738	1.1525	3.7335	0.05	---
	Range	8.9498- 9.4584	2.6052- 3.1420	-0.4585- -0.1054	-0.1411- 0.8686	1.32- 4.96	32.92- 34.55	60.48- 65.76	7.55- 7.62	---
RS-cores										
Upper 0 - 10 cm	Mean	9.4620	2.5927	-0.1520	-0.4472	0.3433	44.0933	55.56	7.16	---
	Std. Dev.	0.6576	0.2050	0.4758	0.0822	0.1550	6.2410	6.1005	0.37	---
	Range	8.9338- 10.1987	2.3906- 2.8005	-0.6913- 0.2088	-0.5413- -0.3887	0.23- 0.52	38.39- 50.76	49.01- 61.08	6.74- 7.41	---
Middle 10 - 24 cm	Mean	9.4213	2.5195	0.0219	-0.4854	0.3933	35.6366	63.9733	7.36	---
	Std. Dev.	0.0815	0.0109	0.0331	0.0556	0.1850	2.3682	2.2451	0.36	---
	Range	9.3450- 9.5072	2.5106- 2.5317	-0.0109- 0.0553	-0.547- -0.4385	0.21- 0.58	33.61- 38.24	61.56- 64.36	7.0- 7.54	---
Lower 24 - 50 cm	Mean	9.2118	2.2702	0.0509	-0.0807	0.4933	34.40	65.110	8.22	6.12
	Std. Dev.	0.3434	0.4468	0.0784	0.5756	0.1258	3.5078	3.3942	1.04	1.46
	Range	8.8365- 9.5103	1.7548- 2.5481	-0.0249- 0.1317	-0.4428- 0.5830	0.36- 0.61	31.96- 38.42	61.23- 67.53	7.48- 9.41	4.75- 7.66

* RH = High marsh; RI = Intertidal; and RS = Subtidal

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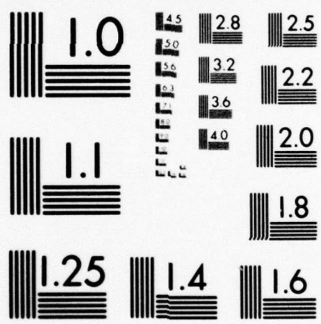

MICROCOPY RESOLUTION TEST CHART

APPENDIX D'

MASS TRANSPORT CALCULATION AND ERROR TERMS

APPENDIX D': MASS TRANSPORT CALCULATION AND ERROR TERMS

By

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1. The mass transport of a given chemical component was determined by a two-step calculation. First, the volume of water transported through each channel or pipe was calculated, and then the mass was determined from parameter concentrations. To perform the volume calculation it was necessary to create two types of support files: one of channel cross-sectional area versus tide height; one of marsh inundation volume versus tide height. A depth profile was taken across each of the channels in order to determine the cross-sectional area. This yielded two one-dimensional matrices, the matrix X_i of distances from one bank of the channel at which the individual depth measurements were taken, and Z_i, the matrix of actual channel depths. The cross-sectional area was then calculated by the following equation:

$$A = \sum_{i=2}^{n} (X_i - X_{i-1})\ (Z_i - Z_{i-1})/2$$

This represents a simple application of the trapezoidal rule which states that the area of a trapezoid is equal to the average of the parallel sides times the height. By varying all of the depths on an incremental basis, files of cross-sectional area versus tide height were created for both reference channels and the artificial breach.

2. The inundation volume of the reference and artificial marshes was calculated using the surface area of the water in each marsh at different tide heights. For this calculation the inundation of both marshes was assumed to have the shape of a pyramid. This was considered a reasonable assumption for a u-shaped channel. Therefore, the volume

of water entering or leaving the marsh due to a change in tide height was calculated using the following equation,

$$D = \frac{1}{3} (H_1 - H_2) (A_1 + A_2 + \sqrt{A_1 A_2}),$$

where D is the volume, H_1 is the beginning tide height, H_2 is the final tide height, A_1 is the surface area of water in the marsh at tide height H_1, and A_2 is the surface area at tide height H_2. Using this equation, files of volume versus change in tide height were created for both marshes.

3. Because of large fluctuations in current velocities during individual field measurements, the field velocities at the artificial breach were averaged during similar tidal periods (four floods, four ebbs, etc.). Then the tide height and average tidal current velocity data files were interpolated to give one observation for every 0.01 hours. From these four types of files a time versus incremental volume file was created for the two pipes and each of the three channels.

4. Incremental volume was calculated in a different manner for each of the marshes. The reason for this will be explained later. Tidal water volumes passing through the two pipes and breach as a result of a change in tide height from H_1 to H_2 and during the time period T_1 to T_2 at the artificial habitat were calculated from the following two equations:

$$V_{AB} = (T_2 - T_1) (S_{T_2} + S_{T_1}) (A_{H_1} + A_{H_2})/4$$

and

$$V_{AP} = D_{H_1 H_2} - V_{AB}$$

V_{AB} and V_{AP} are the volumes at the breach and pipe, respectively, and S_{T_2} and S_{T_1} are the average current velocities at the breach at times T_2 and T_1. A_{H_1} and A_{H_2} are the breach cross-sectional areas at tide heights H_1 and H_2, and $D_{H_1 H_2}$ is the inundation volume of the marsh between tidal heights H_1 and H_2. The volume through the breach is the product of time, average cross-sectional area, and average velocity. The volume through the pipes is simply the difference of the total volume

exchanged and the volume through the breach. These calculations were performed for every 1/100 of an hour over the entire sampling period.

5. A similar volume calculation was attempted for the reference marsh using cross-sectional areas and current velocities at the large channel. This, however, yielded volumes through the small channel which were consistently larger than the volumes through the large channel. This was considered unreasonable and used as criteria for rejection of the current velocity data collected at the large reference channel. Measurements had been made with an Endeco Model 160 intended for use with higher current velocities than occurred in the marsh channels. The channel cross-sections at the reference marsh (see Figure 11) were similar in shape but not in width. As a first approximation, channel cross-sectional areas were considered to be the principal factor determining tidal volumes while current velocities through the two channels were considered equal. Based on this assumption, the volume of water passing through the large and small reference channels RL and RS due to a tide height change from H_1 to H_2 were calculated from the following equations:

$$V_{RL} = (D_{H_1 H_2})(A_{LH_1} + A_{LH_2})/(A_{LH_1} + A_{LH_2} + A_{SH_1} + A_{SH_2})$$

$$V_{RS} = D_{H_1 H_2} - V_{RL}$$

V_{RL} and V_{RS} are the volumes through the large and small channels respectively, A_{LH_1} and A_{LH_2} are the cross-sectional areas of the large reference channel at tide heights H_1 and H_2, and A_{SH_1} and A_{SH_2} are the cross-sectional areas of the small reference channel at tide heights H_1 and H_2. The above equations simply represent an allocation of the total volume according to the ratio of the cross-sectional areas of the two channels. As before, incremental volumes were calculated for every 1/100 of an hour over the entire sampling period.

6. There were two different types of parameter concentration data used in the mass transport calculations--serial data with observations taken hourly, and composite data with a single observation which represented an entire flood or ebb cycle. Serial data were treated by first interpolating or extrapolating missing values wherever possible. The

file was then interpolated so that there was an observation every 100th of an hour. Mass transport of a given chemical component at the pipes or any of the channels was calculated from the following equation by summing over the appropriate time increment:

$$M = \sum_{i=j}^{n} C_i V_i$$

In this equation M is the mass for some flood or ebb cycle, C_i is the interpolated concentration, and V_i is the incremental volume at the channel or pipe being treated.

7. Composite data had to be treated differently, since there was only one concentration value for each flood or ebb cycle. Mass transport was calculated by summing the incremental volume over the appropriate time interval and multiplying by the concentration as illustrated in the equation below.

$$M = C \sum_{i=j}^{n} V_i$$

Here M is the mass for some ebb or flood cycle, C is the composite concentration, and V_i is the incremental volume at the channel or pipe being treated.

8. There were two types of error associated with the mass flux calculations in either the ebb (loss) or flood (gain) portion of each tidal cycle at each one of the locations (channels or pipes) during the two different seasons. These were a concentration error and a velocity error associated with the volume calculation. Since the number of field velocity measurements was insufficient to calculate variances, it was assumed that the error in the averaged velocity measurement used in the volume term for the calculation of mass was approximately ±20 percent. This would also include errors associated with the calculation of surface inundation area from topographic surveys, tidal height, and cross-sectional areas at each channel. The following equation incorporates these errors:

$$S_{F,E}^2 = \frac{(S_T^2)(V_T^2)}{n} + \frac{(\sigma^2)(M_T^2)}{n'}$$

where the first term was the error for the measurements of parameter concentrations and the second term was associated with the volume calculation. Symbols are defined as

$S_{F,E}^2$ = variance in mass for either flood (F) or ebb (E) tide

S_T = standard deviation for the parameter during F or E at each location (AP, AB, RL. RS) for specified time (August 1976 or January 1977; see Appendix C')

V_T = volume transport of tidal water for F or E at each location for specified time (see Tables 49 and 50)

n = number of samples measured (serial or composite) for F or E at each location for specified time (see Appendix C')

σ = standard deviation in the volume error (assumed ±20 percent; $\sigma = 0.1$)

M_T = mass transport of the parameter for F or E at each location for specified time

n' = maximum number of measurements of tidal velocity during F or E at each location for specified time

The net mass transport error was calculated as

$$E = \left[(S_F)^2 + (S_E)^2 \right]^{\frac{1}{2}}$$

9. Particulate metals were not measured hourly (serial) or as a tidally composited sample for every flood and ebb (four of each), but rather as a composited sample for all similar tidal stages during the 48- or 54-hr sampling period. Consequently, a different method of error calculation was employed using the variability in suspended solids data as follows:

$$S_{SC} = \frac{(V_T^2)(S_{SS}^2)(M_T^2)}{N_{SC}} \div 10^{12}$$

Here S_{SC} is the standard deviation of suspended solids contribution to the mass error for a specific tide (T) in units of kg, S_{SS} is the standard deviation of suspended solids (mg/l) for a specific tide, and N_{SC} is the number of samples for suspended solids. This calculation was executed for flood and ebb tides at each location during August 1976 and January 1977. Two other errors were needed to calculate the mass error associated with particulate metals during each tide at each site. The first was

$$S_V = \frac{(\sigma^2)(MS_T^2)}{n'}$$

where σ and n' were defined previously, S_V is the standard deviation of volume error contribution to the calculation of mass, and MS_T is the mass of a particulate metal for a specific tide, site, and season. The second was

$$S_M = \frac{(S_{MET}^2)(MS_T^2)}{n'}$$

where S_M is the standard deviation of mass error associated with the measurement of the metal concentration, and S_{MET} is the standard deviation of the metals concentration (±20 percent; see Appendix B'). If $S_{MET} = 0.1$ and $\sigma = 0.1$, then $S_{MET} = \sigma$, and the mass error for each tide (flood or ebb) is

$$S_{F,E} = \left[(S_{SC})^2 + (S_V)^2 + (S_M)^2\right]^{1/2}$$
$$= \left[(S_{SC})^2 + 2(SV)^2\right]^{1/2}$$

As before, the net mass transport error is the root mean square of the variance for each tide.

10. The flux of particulate metals was calculated for each flood and ebb tide at each location during the summer and winter seasons as follows:

$$MS_T = (V_T)(SS_T)(M_T) \div 10^{12}$$

where MS_T is mass in kg, V_T is the volume (ℓ) for each tidal cycle (T), SS_T is the suspended solids concentration (mg/l), and M_T is the particulate metal concentration (µg/g).

11. Because of the differences in total tidal volume entering and leaving the two marshes, the net mass transport term was multiplied by a factor for the purpose of volume normalization. This factor was the ratio of the larger over the smaller tidal volumes at each site during each season. This should equate the mass transport term to an equal volume basis whereby a loss or gain from the marsh in the net mass transport would not be attributed to an unequal weighting associated with a difference in the tidal volume term.

APPENDIX E'

ANALYSIS OF VARIANCE FOR THE WINDMILL POINT MARSH DEVELOPMENT SITE, JAMES RIVER, VIRGINIA

APPENDIX E': ANALYSIS OF VARIANCE FOR THE WINDMILL POINT MARSH DEVELOPMENT SITE, JAMES RIVER, VIRGINIA

By

Robert A. LaBudde
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Description of the Experiment

1. During two days in August 1976 and three days in January 1977, measurements of physical and chemical variables were made at two sites according to a factorial design: a natural reference marsh (marsh R), and an artificially made experimental marsh (marsh A). One goal of the experiment was to determine any differences between the two marshes large enough to be a detrimental [illegible]. To this end, data were collected serially in time over four tidal cycles (the period of one cycle was 12.42 hours). This was done at two stations (AP and AB, RL and RS) for water quality at each marsh during both day (D) and night (N) tidal cycles and was time-blocked into two 25-hour periods (blocks 1 and 2). In addition, two replicates (α and β) were taken for many of the data at the same time at the same site. The ANOVA (Analysis of Variance) was carried out separately on the ebb (E) and flood (F) tide data.

2. Generally speaking, the experiment was [illegible] 2^6 factorial design (M = marsh, S = station, D = day/night, B = block, T = tide, R = replicate), for which the hourly tidal groups were pooled using the method of unweighted means. Many of the data were not replicated (no replicate vs. replicate), and others were physically pooled before chemical analysis (serial vs. composite data). The serial data were not pooled.

3. [illegible]re were four different measures of uncontrolled error: variation with[illegible] hourly serial data within a tidal phase (s^2/n_h); variatio[illegible] between repli[illegible]s α and β (R); variation between time blocks 1 [illegible] 2 (B); and varia[illegible]ssociated with third and higher order intera[illegible]s (HO = high-order) [illegible] ANOVA. With few exceptions, the differe[illegible]easures of error were mutual[illegible]sistent. In calculating the signific[illegible] of observed effects, the[illegible]ates (R), if measured, were used f[illegible] mean-square-error (MSE); oth[illegible]e blocks (B) were used. In [illegible]tain cases the tidal group var[illegible]$^2/n_h$) was used. Only th[illegible] terms significant at the five per[illegible]el or lower are noted[illegible] the tables.

4. Before describing [illegible]reduction techni[illegible] in detail, contributing factors will be disc[illegible]

M (Marsh): Although [illegible] was to d[illegible]ine physical and chemical di[illegible]et[illegible] naturally occurring and artificia[illegible]arshes, the comparison was made only w[illegible]ural marsh. Data were not collected wh[illegible]ld [illegible] used to measure differences [illegible]ween [illegible]o natural marshes. This is par[illegible]ly [illegible]tant [illegible]nce both significant mar[illegible] Station [illegible]ences were observed, indicat[illegible] possible ge[illegible]ical [illegible]ctor separate from t[illegible]atural-artificia[illegible] distincti[illegible]

S (Stations): Each [illegible]sh had two drain-off [illegible] channels noted a[illegible]ations. The stations we[illegible] A or B [illegible]ther than AP and AB at the ar[illegible] marsh and RL and RS at the reference marsh. [illegible] was no physical relationship between these [illegible]ons. Consequently, a significant station (S) [illegible]ect indicates either (1) a significant differ[illegible] between the stations on one or both marshes[illegible] (2) a general geographical spatial variance w[illegible]in the marsh. The first of these two would be indi[illegible]cated by the concomitant presence of a significant second-order Marsh-Station (MS) interaction (two

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Short Description of the Experiment

1. During two days in August 1976 and three days in January 1977, measurements of physical and chemical variables were made at two sites according to a factorial design: a natural reference marsh (marsh R), and an artificially made experimental marsh (marsh A). One goal of the experiment was to determine any differences between the two marshes large enough to be a detrimental effect. To this end, data were collected serially in time over four tidal cycles (the period of one cycle was 12.42 hours). This was done at two stations (AP and AB, RL and RS) for water quality at each marsh during both day (D) and night (N) tidal cycles and was time-blocked into two 25-hour periods (blocks 1 and 2). In addition, two replicates (α and β) were taken for many of the data at the same time at the same site. The ANOVA (Analysis of Variance) was carried out using only the ebb (E) and flood (F) tide data.

2. Generally speaking, the experiment was of the 2^6 factorial design (M = marsh, S = station, D = day/night, B = block, T = tide, R = replicate), for which the hourly tidal groups were pooled using the method of unweighted means. Many of the data were not replicated (no replicate vs. replicate), and others were physically pooled before chemical analysis (serial vs. composite data). The serial data were not pooled.

3. There were four different measures of uncontrolled error: variation with the hourly serial data within a tidal phase (s^2/n_h); variation between replicates α and β (R); variation between time blocks 1 and 2 (B); and variation associated with third and higher order interactions (HO = high-order) in the ANOVA. With few exceptions, the different measures of error were mutually consistent. In calculating the significance of observed effects, the replicates (R), if measured, were used for mean-square-error (MSE); otherwise the blocks (B) were used. In certain cases the tidal group variation (s^2/n_h) was used. Only those terms significant at the five percent level or lower are noted in the tables.

4. Before describing the data reduction techniques in detail, contributing factors will be discussed:

M (Marsh): Although the goal was to determine physical and chemical differences between naturally occurring and artificially created marshes, the comparison was made only with one natural marsh. Data were not collected which could be used to measure differences expected between two natural marshes. This is particularly important since both significant marsh and station differences were observed, indicating a possible geographical factor separate from the natural-artificial distinction.

S (Stations): Each marsh had two drain-off tidal channels noted as stations. The stations were coded A or B rather than AP and AB at the artificial marsh and RL and RS at the reference marsh. There was no physical relationship between these stations. Consequently, a significant station (S) effect indicates either (1) a significant difference between the stations on one or both marshes, or (2) a general geographical spatial variance within the marsh. The first of these two would be indicated by the concomitant presence of a significant second-order Marsh-Station (MS) interaction (two

stations differ more on one marsh than on the other).

D (Day/Night): The period of the tidal cycle was 12.42 hours, not 12 hours. Consequently, a certain amount of confounding of the D, B, and T effects was bound to occur. Presence of a time versus a day/night effect would be indicated by concomitant significance of DT, DB, T, or TB terms.

B (Blocks): There were approximately two ebb and two flood tides per day, and measurements were continued over a two to three day period. In the August data, complete time blocking occurred and the B factor was used for the ANOVA. With few exceptions, no significant B effects occurred (exceptions included, for example, temperature). In January, the first ebb cycle was missed. In order to maximize use of the data, the B factor was dropped and the ebb tide data from day 3 introduced. Comparison of the within-tidal group variance (s^2/n_h) for the two cases of with-B and without-B for January indicated no significant differences (justifying the dropping of the B factor).

T (Tide): Only inflow (flood) and outflow (ebb) data were used in the ANOVA. Each tide condition was characterized by two to five one-hour interval sample collections, except for the physically composited samples. These hourly data were pooled for the ANOVA using the method of unweighted means. The within-tide hourly variance (divided by the haromonic mean n_h of the number of measurements) was used as an estimate of the mean-square error (MSE).

R (Replicates): At the same time and at the same location (within one meter) two replicates were collected. It was not known whether the replicates were randomized or consistently taken from the exact same locations,

e.g., the right and left sides of the channel. The variance between replicates was a measure of uncontrolled experimental factors, and was used as an estimate of MSE.

Data Reduction Techniques

Data

5. The data were keyed into disk-files in time sequence order, with a code value of -1000 for missing data. All data files of the same type had the same number of entries (e.g., 196 for 8/76 no replicate).

Coding

6. A master code file for each block of data was prepared and checked by two other persons. The same code file was used for 3 to 15 data files. The code files contained six element strings of numbers (digits) in the same sequence as the row data, e.g.,

1	1	1	1	1	1
1	1	1	1	1	2
1	1	1	1	1	1
1	1	1	1	1	2
0	0	0	0	0	0
1	1	1	1	2	1

etc

The codes used are listed in the table on the following page. The code string 0 0 0 0 0 0 corresponded to missing data or data that were not used (e.g., slack tides). Since some of the data were collected hourly, similar code strings occurred for a sequence of 2-5 data as time replicates.

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etc.

The codes used are listed in the table on the following page. The code string 0 0 0 0 0 0 corresponded to missing data or data that were not used (e.g., slack tides). Since some of the data were collected hourly, similar code strings occurred for a sequence of 2-5 data as time replicates.

Digit	Value	Factor Name	Level
1	1	Marsh (M)	Artificial
	2	Marsh (M)	Reference
2	1	Station (S)	A
	2	Station (S)	B
3	1	Day/Night (D)	Day
	2	Day/Night (D)	Night
4	1	Block (B)	25-hour Cycle 1
	2	Block (B)	25-hour Cycle 2
5	1	Tide (T)	Ebb
	2	Tide (T)	Flood
6	1	Replicate (R)	α
	2	Replicate (R)	β

Unweighted means for numerical compositing

7. In order to put the data into a factorial design for the ANOVA, they were first numerically composited using the method of unweighted means. The row-data were averaged over the hourly components of each tidal phase via

$$\overline{x}_{i_1 i_2 i_3 i_4 i_5 i_6} = \frac{1}{n_{i_1 i_2 i_3 i_4 i_5 i_6}} \sum_{t=1}^{n_{i_1 i_2 i_3 i_4 i_5 i_6}} x_{i_1 i_2 i_3 i_4 i_5 i_6, t}$$

where $i_1 i_2 i_3 i_4 i_5 i_6$ was the code string and $n_{i_1 i_2 i_3 i_4 i_5 i_6}$ was the number of data within the tidal cycle (number of time replicates). On the average (over all codes), each $\overline{x}$ represented approximately n_h data, where n_h was the harmonic mean of the $n_{i_1 i_2 i_3 i_4 i_5 i_6}$

$$\frac{1}{n_h} = \frac{1}{N} \sum^{N} \frac{1}{n_{i_1 i_2 i_3 i_4 i_5 i_6}} \quad ,$$

and N = 32 for five factors (no replicate samples), or N = 64 for six factors (replicate samples).

8. Since there were time replicates, an estimate of the hourly variance of the raw data was also found:

$$s^2 = \frac{1}{D.F.} \sum \sum (x_{i_1 i_2 i_3 i_4 i_5 i_6, t} - \bar{x}_{i_1 i_2 i_3 i_4 i_5 i_6})^2$$

where

$$D.F. = \sum (n_{i_1 i_2 i_3 i_4 i_5 i_6} - 1)$$

9. An estimate of the mean-square error (MSE) of the $\bar{x}'s$ was found from s^2, which was the residual error after all factor effects were removed:

$$s^2/n_h$$

This estimate was only approximate because of the inhomogeneity of the variances of the $\bar{x}$'s.

Missing data

10. Missing data (0 to 3 per variable) were filled by use of the corresponding replicate or corresponding block, whichever was available. The degrees of freedom used in the MSE were correspondingly reduced.

Analysis of variance

11. An analysis of variance (ANOVA) was performed for the factorial design (all combinations of codes) of the unweighted means. An ANOVA examines the terms in a least-squares fit of the data by seeing how much of the variance of the data is accounted for by each term. An F-test (square of a t-test) is used to test if each term is significant statistically.

12. For example, if three factors A, B, C were used in a 2^3 design, the least-squares fit would be to the model.

$$x = \mu + \underbrace{A + B + C}_{\text{linear or 1st order terms}} + \underbrace{AB + AC + BC}_{\text{quadratic or 2nd order terms}} + \underbrace{ABC}_{\text{cubic or 3rd order terms}}$$

mean value

Except that each factor takes on only two values, the fitting procedure is identical to a fit of a polynomial of the highest possible degree.

Meaning of the ANOVA Terms

13. First order terms:

M - Used to interpret a difference between the average value for marsh 1 and that for marsh 2.

S - Since there were no physical relations between tidal channels on the two marshes, the meaning of this term was confounded with the M effect.

D - Used to interpret a difference between the average values for day and night.

B - Since no systematic effects were normally to be expected between 25-hr cycles, the terms included in the block effect were considered a measure of irreproducibility, or random variation. (Note that some physical effects do occur between blocks, such as differences in the mean ambient temperatures.)

T - Used to interpret a difference between the averages for ebb and flood tides.

R - Replicates were a measure of the irreproducibility in the sampling procedures, and all terms with an R were used as an estimate of random error.

14. Second order terms:

MT - For evaluating a difference between marsh averages which were caused by the change from ebb to flood tides, or used to interpret the ebb-tide difference on the

experimental marsh versus the ebb-tide difference on the reference marsh.

15. Third order terms:

These terms, such as MSD, MST, SDT, etc., were considered too complicated to be of physical significance and were considered an estimate of the mean-square error (MSE), labeled high order (H-O).

Interpretation of the ANOVA

Significance

16. Statistical significance was measured by the ratio of the variance attributed to the effect (such as M) to the MSE. The estimate of the MSE was the composite of all R terms for replicate data, or all B terms for no-replicate data.

Size	Statistical Term	Abbrev.	English Equivalent
$>F_{.05}$	Significant	S	Detectable
$>F_{.01}$	Very significant	VS	Easily detectable
$>F_{.001}$	Very, very significant	VVS	Noticeable

Note that $F_{.05} \sim 4$, $F_{.01} \sim 8$, $F_{.001} \sim 17$, where the F value is approximately the square of the signal/noise ratio.

17. Once the statistical test has indicated that the effect observed was meaningful in that it was separated from background, it makes sense to discuss the physical meaning of such results. For example, it may be possible to easily measure a 0.001-mm difference in the length between two bars, but this is of no importance if the bars are to be used as table legs. Remember that any difference can be detectable if enough data are collected. Suppose the M effect was determined as significant statistically. The physical significance can be found as follows. Let Δ be the difference in average values observed on marshes 1 and 2:

$$\Delta = |\overline{x}_1 - \overline{x}_2|$$

Then, this number is compared to the grand mean of the data, $\overline{x}$:

Value $r = \Delta/\overline{x}$	Term Used
$r < 0.01$	Negligible effect
$0.01 < r < 0.1$	Small effect
$0.1 < r < 1$	Important effect
$r > 1$	Overwhelming effect

When many terms are examined, 1 in 20 can be expected to be significant due to coincidence, 1 in 100 to be very significant, and 1 in 1000 to be very, very significant. Furthermore, the applicability of very low significance levels, such as 0.1 percent, can be questioned when it is not known how well the data are normally distributed, particularly when the method of unweighted means is used.

Measures of error

18. We have four not quite independent measures of mean-square error (MSE):

	Due To	Abbrev.	Comments
Increasing Expected Size ↓	Replicate	R	Error due to physical sampling of α and β at the same tide during the same hour
	Tidal phase	s^2/n_h	Hourly variation of replicates during the same tide
	High-order terms	High order or H-O	Average estimate of total error in the means
	Blocks	B	Variation observed between days, which includes replicate, tidal cycle, and daily variations

19. The ideal situation is when all four estimates provide values for the MSE which are not significantly different (i.e., don't vary more than about a factor of 2, $F^{.05}_{16,\infty} = 2.01$, $F^{.05}_{32,\infty} = 1.6$). This happy condition was the case for almost all of the measured variables.

<u>A specific example</u>

20. Consider the ANOVA for August 1976 pH (no replicates):

1. Each tidal phase had about two data ($n_h = 2.327$).
2. $s^2 = 0.074$ ($s = 0.272$) (57 degrees of freedom), i.e., hour-to-hour variations in pH were observed to be about $\pm 2s$ or ± 0.5 units.
3. The observed data ranged from 6.63 to 7.98 or 1.35 pH units.

21. From the ANOVA:

4. The mean pH observed was 7.26 (about midrange).
5. The three measures of MSE were

   $s^2/n_h = 0.032$

   H-O = 0.070 (16 degrees of freedom)

   B = 0.041 (16 degrees of freedom)

   Here the B and s^2/n_h values agree, but H-O was larger for some reason (but not exceptionally so). Investigation showed that the H-O value was greatly affected by a large number for the MDT term, which indicated a pH difference between marshes during the night and day for different tides.
6. The M effect was barely detectable (with an F-value of 4.3).
7. The D effect was very significant, indicating an observable day-night difference (with an F-value of 9.2).
8. A clear tidal effect (T) was found (with an F-value of 31). The DT and MDT terms reinforced the presence of T and D effects.

9. The size of the T effect was a difference of 0.23 in pH between ebb and flood tides, which was not extremely important when the hourly differences of $0.5 \div 2.3 \approx 0.2$ were considered.

22. Comments for August 1976 data:

1. B effects were observed for water temperature, total dissolved organic carbon, and volatile dissolved organic carbon, due to daily variations.

2. Because of the large accountable B effect for water temperature, s^2/n_h was used for the measure of MSE for significance testing.

23. Comments for January 1977 serial replicate data:

1. Significant effects due to the B factor were not observed.

2. R, H-O, and s^2/n_h agreed as estimates of MSE.

3. The M, S, and MS factors were significant, indicating a geographical effect for the two marshes.

4. There was a slight indication of a T or D effect.

24. For the serial no-replicate data during August and January:

1. Noticeable B effects were not observed.

2. Generally there was agreement between H-O and s^2/n_h terms as measures of MSE.

3. A strong M effect was observed for most of the variables.

4. There was evidence of D or T effects.

25. For the composited replicate data during August and January:

1. Generally there was agreement between R, H-O, and s^2/n_h as measures of MSE.

2. Strong M, S, and MS effects indicated a geographical factor associated with the data.

3. There was evidence of D or T (time) effects.

Table E'1

Analysis of Variance (ANOVA) for Serial Replicate Ebb and Flood Tide Data from the James River Artificial Habitat Development Site and a Reference Marsh During August 1976 and January 1977

Parameter	Grand Mean	S	Terms	Significant Terms: Mean Square	Significant Terms: F-value	Level of Significance	Replicates	Estimate of Mean-Square Error: Tidal-Phase	Estimate of Mean-Square Error: High-order		Blocks
August 1976								*	*		
Dissolved Calcium	14.65	1.9	marsh	48.4	33.1	VVS	1.464	1.33	0.968		1.262
			stations	8.5	5.8	S					
			MR	12.8	8.7	VS					
			DB	6.8	4.7	S					
Dissolved Iron	0.343	0.29	marsh	0.218	15.2	VVS	0.0143	0.310	0.0195		0.259
			stations	0.138	9.6	VS					
			tide	0.127	8.9	VS					
			MS	0.131	9.2	VS					
			TR	0.120	8.4	VS					
			MB	0.105	7.4	S					
Dissolved Manganese	0.086		marsh	0.088	47.0	VVS	0.0019	0.0010	0.0038		0.0014
			tide	0.014	7.2	S					
			day/night	0.013	6.8	S					
			BT	0.015	8.2	VS					
			MB	0.010	5.2	S					
Dissolved Zinc	0.082		stations	0.0050	6.0	S	0.00083	0.00067	0.00084		0.00074
			MS	0.0057	6.9	S					
January 1977**										W/O B†	W/B†
Dissolved Calcium	12.68		marsh	26.9	(93.1)*	(VVS)*	0.613	0.289	0.357	2.097	1.724
			replicates	2.16	(7.5)	(VS)					
			stations	2.02	(7.0)	(VS)					
			MR	5.05	(17.5)	(VVS)					
Dissolved Iron	0.275		marsh	0.010	46.8	VVS	0.0022	0.0030	0.0018	0.0218	0.0243
			DT	0.018	81.8	VVS					
Dissolved Manganese	0.041		marsh	0.0057	264 (24)*	VVS (VVS)*	0.000022	0.000024	0.000093	0.0018	0.0020
			stations	0.0021	96 (8.6)	VVS (VS)					
			tide	0.0011	49 (4.4)	VVS (S)					
			MS	0.0017	81 (7.3)	VVS (VS)					
Dissolved Zinc	0.055		stations	0.0028	(30.3)*	(VVS)*	0.00052	0.00010	0.00010	0.00068	0.00068
			marsh	0.0023	(25.6)	(VVS)					
			replicates	0.0010	(10.5)	(VS)					
			DR	0.0052	(57.5)	(VVS)					
			MS	0.0009	(10.3)	(VVS)					

High-order is ≤ 3rd order of terms.

* For January 1977 dissolved metals, the tidal phase was used as a measure of MSE for dissolved calcium and zinc because the replicate factor was significant. These data are shown in parenthesis

** No B (block) factor for January 1977 data

† The with and without blocks indicated no significant difference, used to determine MSE within tidal cycle alone, versus the tidal phase (s^2/n_h) which includes B variations

Table E'2

Analysis of Variance (ANOVA) for Serial No-Replicate Ebb and Flood Tide Data from the James River Artificial Habitat Development Site and a Reference Marsh During August 1976

Parameter	Grand Mean	Standard Deviation	Missing Data	Significant Terms: Term	Significant Terms: Mean Square	Significant Terms: F-value*	Level of Significance	Estimate of Mean Square Error: Tidal Phase	Estimate of Mean Square Error: High-order	Estimate of Mean Square Error: Blocks
Temperature	26.36	0.61		day/night	6.8	(51.1)	VVS	0.133	0.22	0.62
				block	3.0	(26.6)	VVS			
				MB	2.7	(20.3)	VVS			
Conductivity	0.169	0.009		marsh	0.00025	5.6	S	0.000031	---	0.000041
				ST	0.00025	5.6	S			
Suspended Solids	38.16	36.7	2	marsh	6510	16.3	VVS	563	267	393
Turbidity	22.8	9.5		marsh	1164	29.6	VVS	34.7	23.3	39.4
				MS	234.7	6.0	S			
pH	7.26	0.27		tide	1.27	31.0	VVS	0.032	0.070	0.041
				day/night	0.378	9.2	VS			
				marsh	0.176	4.3	---			
				DT	0.388	9.5	VS			
Dissolved Oxygen	6.18	0.85	2	marsh	12.9	28.5	VVS	0.27	0.42	0.45
				tide	7.1	15.7	VS			
				day/night	3.0	6.6	S			
Oxygen Saturation	75.8	10.5	2	marsh	2091	27.0	VVS	41.0	66.3	77.6
				tide	926	11.9	VS			
				day/night	592	7.6	S			
				DT	3731	48.1	VVS			
				MT	397	5.1	S			
Fo/Fa Ratio	1.74	0.08		day/night	0.0196	4.7	S	0.0026	0.0056	0.0042
Chlorophyll	11.79	3.6		marsh	66.4	14.7	VS	5.2	3.8	4.5
				tide	21.6	4.8	S			
				MD	38.1	8.4	S			
Phaeophytin	4.30	1.7		marsh	13.9	13.5	VS	1.15	1.7	1.0
				day/night	7.4	7.2	S			
Total Dissolved Organic Carbon	9.45	4.67	1	DB	122	(13.1)	VS	9.3	27.5	39.2
Volatile Dissolved Organic Carbon	1.95	1.29	1	tide	13.8	5.8	S	0.71	2.25	2.37
				marsh	8.5	3.6	--			
Dissolved Orthophosphate	0.049	0.011	16**	None				0.000043	0.000030	0.000071
Dissolved Nitrate and Nitrite	0.67	0.20	16**	None				0.006	0.0301	0.0392

High order is ≤ 3rd order terms

*For F-value: $F_{0.001,1,16} = 16.1$ (VVS); $F_{0.01,1,16} = 8.5$ (VS); $F_{0.05,1,16} = 4.5$ (S); $F_{0.1,1,16} = 3.05$; see text for VVS, VS, S levels; blocks were used for MSE to determine significant interactions (terms in parenthesis used tidal phase MSE)

** The station factor was dropped because these were analyzed from serial samples for AB alpha and RS alpha only

Table E'3

Analysis of Variance (ANOVA) for Serial No-Replicate Ebb and Flood Tide Data from the James River Artificial Habitat Development Site and a Reference Marsh During January 1977

			Significant Terms*				Estimate of Mean Square Error			
Parameter	Grand Mean	S	Term	Mean Square	F-value	Level of Significance	Tidal-Phase	High-order	W/O B**	W/B**
Temperature	0.65	0.49	tide	2.45	56	VVS	0.0435	0.24	0.24	0.19
			marsh	0.636	14.6	VVS				
			day/night	0.612	14.1	VVS				
			MT	1.46	33.6	VVS				
			DT	1.42	32.6	VVS				
			MD	0.704	16.2	VVS				
Conductivity	0.152	0.058	marsh	0.034	56.4	VVS	0.0006	0.0004	0.0033	0.0036
Suspended Solids	26.2	16.1	MS	239	4.9	S	49.0	124.6	260	283
Turbidity	13.3	6.0	marsh	128	19.8	VVS	6.5	6.2	36.0	33.8
			day/night	32.1	5.0	S				
			stations	28.0	4.3	NS				
			MS	31.2	4.8	S				
pH	7.75	0.24	marsh	1.50	144	VVS	0.0104	0.0059	0.058	0.018
			MD	0.089	8.6	VS				
Alkalinity	0.448	0.14	day/night	0.072	19.7	VVS	0.0037	0.0037	0.020	0.018
			marsh	0.049	13.3	VS				
			MD	0.027	7.4	S				
Dissolved Oxygen	11.72	0.66	marsh	4.97	59.4	VVS	0.0836	0.080	0.436	0.394
			tide	0.45	5.4	S				
Oxygen Saturation	83.1	4.7	marsh	172	39	VVS	4.39	7.35	22.3	19.3
			tide	63	14.2	VVS				
			MT	23	5.3	S				
Fo/Fa Ratio	1.49	0.063	marsh	0.024	33.4	VVS	0.00073	0.00008	0.0039	0.0031
			DT	0.0055	7.5	VS				
			MT	0.0030	4.1	S				
Chlorophyll	0.739	0.16	NONE				0.0051	0.0102	0.027	0.027
Phaeophytin	0.829	0.36	marsh	0.303	12.2	VS	0.025	0.027	0.133	0.122
			tide	0.201	8.1	VS				
			DT	0.286	11.5	VS				
Particulate Organic Carbon	1.48	0.94	MS	0.73	4.4	S	0.164	0.33	0.89	0.94
Total Dissolved Organic Carbon	8.26	2.9	MS	17.4	11.2	VS	1.55	2.17	8.4	6.4
Volatile Dissolved Organic Carbon	1.69	0.60	marsh	3.91	59.2	VVS	0.07	0.14	0.36	0.26
			MT	1.17	17.7	VVS				

High-order ≤ 3rd order terms

* Using tidal-phase (s^2/n_h) as mean square error (MSE)

** Only a slight inflation in MSE because the block was dropped (not significant), therefore the days were pooled to add the last ebb cycle. B (block) factor was not used for all the data

Table E'4

Analysis of Variance (ANOVA) for Composite No-Replicate* and Replicate** Ebb and Flood Tide Data from the James River Artificial Habitat Development Site and a Reference Marsh During August 1976

Parameter	Grand Mean	Std. Dev.	Missing Data	Significant Terms: Terms	Mean Square	F-value	Level of Significance	Estimate of Mean Square Error: Replicates	Tidal phase	High-order	Blocks
Total Phosphorus*	0.176	—	2	marsh	0.0138	6.9	S			0.0018	0.0020
Total Dissolved Phosphorus**	0.086	—		replicates stations MS DT	0.0065 0.0050 0.165 0.0029	11.7 9.0 29.6 5.2	VS VS VVS S	0.00056		0.00057	0.00051
Dissolved Phosphate**,†	0.055	0.021	No replicates‡	marsh tide MS	0.0066 0.0025 0.0012	54.8 20.6 10.1	VVS VVS VS		0.00033	0.00011	0.00012
Total Kjeldahl Nitrogen*	4.92	—	2	NONE						3.06	3.29
Total Dissolved Nitrogen**	2.73	—		marsh MR MT	71.2 11.6 10.2	77.3 12.6 11.1	VVS VS VS	0.921		1.03	1.07
Dissolved Ammonium**	0.618	—		MS MB DB SD	0.189 0.189 0.089 0.064	24.5 24.5 11.5 8.3	VVS VVS VS VS	0.0008		0.0123	0.0211
Dissolved Ammonium*	0.476	—		MS	0.502	4.6	S			0.0099	0.0109
Dissolved Nitrate plus Nitrite**,†	0.570	0.10	No replicates‡	marsh	0.281	21.8	VVS		0.0081	0.0129	0.0128
Dissolved Mercury**,††	0.525 µg/l	—		block DB	0.378 0.403	4.5 4.8	S S	0.0842		0.0825	0.122

High-order is ≤ 3rd order terms

* ANOVA as composite data with no-replicates

** ANOVA as composite data with replicates

† See Table E' 2 for ANOVA for serial data with no-replicates from AB alpha and RS alpha samples only

†† See Table E' 1 for ANOVA for serial replicate data of other metals

‡ Analyzed as composite no-replicate because of the missing data

Table E'5

Analysis of Variance (ANOVA) for Composite Replicate Ebb and Flood Tide Data from the James River Artificial Habitat Development Site and a Reference Marsh During January 1977

Parameter	Grand Mean	Standard Deviation	Significant Terms: Terms	Mean Square	F-value*	Level of Significance	Estimate of Mean Square Error: Replicates	Tidal-Phase**	High-order
Total Phosphorus	0.205	0.031	marsh	0.019	77.4	VVS	0.00025	0.00046	0.00048
			stations	0.0052	20.8	VVS			
			day/night	0.0021	8.4	VVS			
			MS	0.0045	17.8	VVS			
Total Dissolved Phosphorus	0.105	0.014	marsh	0.00082	23.4	VVS	0.00004	0.00009	0.00005
			stations	0.00066	18.9	VVS			
			day/night	0.00061	17.5	VVS			
			MS	0.0023	66.4	VVS			
Dissolved Phosphate	0.039	0.0071	marsh	0.00086	17.2	VVS	0.000050	0.000024	0.000030
			replicates	0.00030	(12.2)*	VS			
			MS	0.00036	7.1	S			
Total Kjeldahl Nitrogen	3.42	1.1	stations	2.64	10.8	VS	0.25	0.63	0.16
			day/night	2.48	10.1	VS			
			MT	1.63	6.6	S			
Total Dissolved Nitrogen	2.60	0.41	stations	0.77	35.0	VVS	0.022	0.082	0.073
			tide	0.24	11.0	VS			
			MT	0.98	44.5	VVS			
			ST	0.38	17.1	VVS			
			MD	0.28	12.9	VS			
Dissolved Ammonium	0.457	0.10	day/night	0.021	7.8	S	0.0026	0.0050	0.0151
			stations	0.018	6.9	S			
			tide	0.011	4.3	~ S			
			ST	0.104	39.4	VVS			
Dissolved Nitrate and Nitrite	1.83	0.47	marsh	0.95	23.8	VVS	0.040	0.11	0.055
			stations	0.60	15.0	VS			
Dissolved Mercury†	0.273	0.20	stations	0.137	(7.2)*	S	0.0024	0.019	0.016
			DT	0.084	(4.4)*	~ S			

High-order is $\leq$ 3rd order terms

* F-value calculated with $S = S^2/n_h$ (tidal phase); all others calculated with replicates

** 36 degrees of freedom, except Dissolved NO_3 and NO_2 with 29 degrees of freedom

† See Table E' 1 for ANOVA for serial replicates data of other metals. Data listed in units of µg/l; others as mg/l